

09/700811

525 Rec'd PCT/PTO 20 NOV 2000

(Re1.82A—12/99 Pub.605)

FORM 13-18

13-159

Practitioner's Docket No. 2497/101

## CHAPTER II

Preliminary Classification:

Proposed Class:

Subclass:

NOTE: "All applicants are requested to include a preliminary classification on newly filed patent applications. The preliminary classification, preferably class and subclass designations, should be identified in the upper right-hand corner of the letter of transmittal accompanying the application papers, for example 'Proposed Class 2, subclass 129.'" M.P.E.P., § 601, 7th ed.

TRANSMITTAL LETTER  
TO THE UNITED STATES ELECTED OFFICE (EO/US)

## (ENTRY INTO U.S. NATIONAL PHASE UNDER CHAPTER II)

|  |  |                                      |
|--|--|--------------------------------------|
| INTERNATIONAL APPLICATION NO.<br>PCT/GB99/01625                | INTERNATIONAL FILING DATE<br>21 May 1999 | PRIORITY DATE CLAIMED<br>22 May 1998 |
| TITLE OF INVENTION<br>A Remote Tire Pressure Monitoring System |  |                                      |
| APPLICANT(S)<br>Leman  |  |                                      |

Box PCT  
Assistant Commissioner for Patents  
Washington D.C. 20231  
ATTENTION: EO/US

**CERTIFICATION UNDER 37 C.F.R. § 1.10\***  
(Express Mail label number is mandatory.)  
(Express Mail certification is optional.)

I hereby certify that this Transmittal Letter and the papers indicated as being transmitted therewith is being deposited with the United States Postal Service on this date 20 November 2000, in an envelope as "Express Mail Post Office to Addressee" Mailing Label Number EL 543501232 US, addressed to the: Assistant Commissioner for Patents, Washington, D.C. 20231.

Timothy M. Murphy

(type or print name of person mailing paper)



Signature of person mailing paper

**WARNING:** Certificate of mailing (first class) or facsimile transmission procedures of 37 C.F.R. § 1.8 cannot be used to obtain a date of mailing or transmission for this correspondence.

**\*WARNING:** Each paper or fee filed by "Express Mail" **must** have the number of the "Express Mail" mailing label placed thereon prior to mailing. 37 C.F.R. § 1.10(b).  
"Since the filing of correspondence under § 1.10 without the Express Mail mailing label thereon is an oversight that can be avoided by the exercise of reasonable care, requests for waiver of this requirement will **not** be granted on petition." Notice of Oct. 24, 1996, 60 Fed. Reg. 56,439, at 56,442.

(Transmittal Letter to the United States Elected Office (EO/US) [13-18]—page 1 of 8)

09/700811

**NOTE:** To avoid abandonment of the application, the applicant shall furnish to the USPTO, not later than 20 months from the priority date: (1) a copy of the international application, unless it has been previously communicated by the International Bureau or unless it was originally filed in the USPTO; and (2) the basic national fee (see 37 C.F.R. § 1.492(a)). The 30-month time limit may not be extended. 37 C.F.R. § 1.495.

532 Rec'd PCT/PTO 20 NOV 2000

**WARNING:** Where the items are those which can be submitted to complete the entry of the international application into the national phase are subsequent to 30 months from the priority date the application is still considered to be in the international state and if mailing procedures are utilized to obtain a date the express mail procedure of 37 C.F.R. § 1.10 must be used (since international application papers are not covered by an ordinary certificate of mailing—See 37 C.F.R. § 1.8.

**NOTE:** Documents and fees must be clearly identified as a submission to enter the national state under 35 U.S.C. § 371 otherwise the submission will be considered as being made under 35 U.S.C. § 111. 37 C.F.R. § 1.494(f).

I. Applicant herewith submits to the United States Elected Office (EO/US) the following items under 35 U.S.C. § 371:

- a. ☒ This express request to immediately begin national examination procedures (35 U.S.C. § 371(f)).
- b. ☒ The U.S. National Fee (35 U.S.C. § 371(c)(1)) and other fees (37 C.F.R. § 1.492) as indicated below:

(Transmittal Letter to the United States Elected Office (EO/US) [13-18]—page 2 of 8)

## 2. Fees

| CLAIMS FEE                            | (1) FOR  | (2) NUMBER FILED | (3) NUMBER EXTRA | (4) RATE   | (5) CALCULATIONS |
|---------------------------------------|--|------------------|------------------|------------|------------------|
| <input checked="" type="checkbox"/> * | TOTAL CLAIMS   | 19-20=           | 0                | × \$18.00= | \$ 0             |
|                                       | INDEPENDENT CLAIMS   | 2-3=             | 0                | × \$78.00= | 0                |
|                                       | MULTIPLE DEPENDENT CLAIM(S) (if applicable) + \$260.00   |                  |                  |            | 0                |
| BASIC FEE**                           | <input type="checkbox"/> U.S. PTO WAS INTERNATIONAL PRELIMINARY EXAMINATION AUTHORITY<br>Where an international preliminary examination fee as set forth in § 1.482 has been paid on the international application to the U.S. PTO:<br><input type="checkbox"/> and the international preliminary examination report states that the criteria of novelty, inventive step (non-obviousness) and industrial activity, as defined in PCT Article 33(1) to (4) have been satisfied for all the claims presented in the application entering the national stage (37 C.F.R. § 1.492(a)(4)) ..... \$96.00<br><input type="checkbox"/> and the above requirements are not met (37 C.F.R. § 1.492(a)(1)) ..... \$670.00<br><input type="checkbox"/> U.S. PTO WAS NOT INTERNATIONAL PRELIMINARY EXAMINATION AUTHORITY<br>Where no international preliminary examination fee as set forth in § 1.482 has been paid to the U.S. PTO, and payment of an international search fee as set forth in § 1.445(a)(2) to the U.S. PTO:<br><input type="checkbox"/> has been paid (37 C.F.R. § 1.492(a)(2)) ..... \$690.00<br><input type="checkbox"/> has not been paid (37 C.F.R. § 1.492(a)(3)) ..... \$970.00<br><input type="checkbox"/> where a search report on the international application has been prepared by the European Patent Office or the Japanese Patent Office (37 C.F.R. § 1.492(a)(5)) ..... \$840.00 |                  |                  |            | 860.00           |
|                                       | Total of above Calculations  |                  |                  |            | =860.00          |
| SMALL ENTITY                          | Reduction by 1/2 for filing by small entity, if applicable. Affidavit must be filed also. (note 37 C.F.R. § 1.9, 1.27, 1.28)   |                  |                  |            | - 430.00         |
|                                       | Subtotal   |                  |                  |            | 430.00           |
|                                       | Total National Fee   |                  |                  |            | \$ 430.00        |
|                                       | Fee for recording the enclosed assignment document \$40.00 (37 C.F.R. § 1.21(h)). (See Item 13 below). See attached "ASSIGNMENT COVER SHEET".  |                  |                  |            |                  |
| TOTAL                                 | Total Fees enclosed  |                  |                  |            | \$ 430.00        |

\*See attached Preliminary Amendment Reducing the Number of Claims.

i. ☒ A check in the amount of 430.00 to 532 Rec'd PCT above fees is enclosed.

ii. ☐ Please charge Account No. \_\_\_\_\_ in the amount of \$ \_\_\_\_\_.  
A duplicate copy of this sheet is enclosed.

**\*\*WARNING:** "To avoid abandonment of the application the applicant shall furnish to the United States Patent and Trademark Office not later than the expiration of 30 months from the priority date: \* \* \* (2) the basic national fee (see § 1.492(a)). The 30-month time limit may not be extended." 37 C.F.R. § 1.495(b).

**WARNING:** If the translation of the international application and/or the oath or declaration have not been submitted by the applicant within thirty (30) months from the priority date, such requirements may be met within a time period set by the Office. 37 C.F.R. § 1.495(b)(2). The payment of the surcharge set forth in § 1.492(e) is required as a condition for accepting the oath or declaration later than thirty (30) months after the priority date. The payment of the processing fee set forth in § 1.492(f) is required for acceptance of an English translation later than thirty (30) months after the priority date. Failure to comply with these requirements will result in abandonment of the application. The provisions of § 1.136 apply to the period which is set. Notice of Jan. 3, 1993, 1147 O.G. 29 to 40.

3. ☒ A copy of the International application as filed (35 U.S.C. § 371(c)(2)):

**NOTE:** Section 1.495 (b) was amended to require that the basic national fee and a copy of the international application must be filed with the Office by 30 months from the priority date to avoid abandonment. "The International Bureau normally provides the copy of the international application to the Office in accordance with PCT Article 20. At the same time, the International Bureau notifies applicant of the communication to the Office. In accordance with PCT Rule 47.1, that notice shall be accepted by all designated offices as conclusive evidence that the communication has duly taken place. Thus, if the applicant desires to enter the national stage, the applicant normally need only check to be sure the notice from the International Bureau has been received and then pay the basic national fee by 30 months from the priority date." Notice of Jan. 7, 1993, 1147 O.G. 29 to 40, at 35-36. See item 14c below.

a. ☐ is transmitted herewith.

b. ☐ is not required, as the application was filed with the United States Receiving Office.

c. ☒ has been transmitted

i. ☒ by the International Bureau.

Date of mailing of the application (from form PCT/1B/308): 2/12/99

ii. ☐ by applicant on \_\_\_\_\_

Date

4. ☒ A translation of the International application into the English language (35 U.S.C. § 371(c)(2)):

a. ☐ is transmitted herewith.

b. ☒ is not required as the application was filed in English.

c. ☐ was previously transmitted by applicant on \_\_\_\_\_

Date

d. ☐ will follow.

(Transmittal Letter to the United States Elected Office (EO/US) [13-18]—page 4 of 8)

5. ☒ Amendments to the claims of the International application under PCT Article 19 (35 U.S.C. § 371(c)(3)):

NOTE: The Notice of January 7, 1993 points out that 37 C.F.R. § 1.495(a) was amended to clarify the existing and continuing practice that PCT Article 19 amendments must be submitted by 30 months from the priority date and this deadline may not be extended. The Notice further advises that: "The failure to do so will not result in loss of the subject matter of the PCT Article 19 amendments. Applicant may submit that subject matter in a preliminary amendment filed under section 1.121. In many cases, filing an amendment under section 1.121 is preferable since grammatical or idiomatic errors may be corrected." 1147 O.G. 29-40, at 36.

- a. ☒ are transmitted herewith.
- b. ☐ have been transmitted
  - i. ☐ by the International Bureau.  
Date of mailing of the amendment (from form PCT/1B/308): \_\_\_\_\_
  - ii. ☐ by applicant on (date) \_\_\_\_\_  
Date
- c. ☐ have not been transmitted as
  - i. ☐ applicant chose not to make amendments under PCT Article 19.  
Date of mailing of Search Report (from form PCT/ISA/210.): \_\_\_\_\_
  - ii. ☐ the time limit for the submission of amendments has not yet expired.  
The amendments or a statement that amendments have not been made will be transmitted before the expiration of the time limit under PCT Rule 46.1.

6. ☒ A translation of the amendments to the claims under PCT Article 19 (38 U.S.C. § 371(c)(3)):

- a. ☐ is transmitted herewith.
- b. ☒ is not required as the amendments were made in the English language.
- c. ☐ has not been transmitted for reasons indicated at point 5(c) above.

7. ☒ A copy of the international examination report (PCT/IPEA/409)

- ☒ is transmitted herewith.
- ☐ is not required as the application was filed with the United States Receiving Office.

8. ☒ Annex(es) to the international preliminary examination report

- a. ☒ is/are transmitted herewith.
- b. ☐ is/are not required as the application was filed with the United States Receiving Office.

9. ☒ A translation of the annexes to the international preliminary examination report

- a. ☐ is transmitted herewith.
- b. ☒ is not required as the annexes are in the English language.

10. ☒ An oath or declaration of the inventor (35 U.S.C. § 371(c)(4)) complying with 35 U.S.C. § 115

532 Rec'd PCT/PTO 20 NOV 2000

- a. ☐ was previously submitted by applicant on \_\_\_\_\_  
Date
- b. ☐ is submitted herewith, and such oath or declaration
- i. ☐ is attached to the application.
- ii. ☐ identifies the application and any amendments under PCT Article 19 that were transmitted as stated in points 3(b) or 3(c) and 5(b); and states that they were reviewed by the inventor as required by 37 C.F.R. § 1.70.
- c. ☒ will follow.

II. Other document(s) or information included:

11. ☒ An International Search Report (PCT/ISA/210) or Declaration under PCT Article 17(2)(a):

- a. ☐ is transmitted herewith.
- b. ☒ has been transmitted by the International Bureau.  
Date of mailing (from form PCT/IB/308): 2/12/99
- c. ☐ is not required, as the application was searched by the United States International Searching Authority.
- d. ☐ will be transmitted promptly upon request.
- e. ☐ has been submitted by applicant on \_\_\_\_\_  
Date

12. ☒ An Information Disclosure Statement under 37 C.F.R. §§ 1.97 and 1.98:

- a. ☐ is transmitted herewith.  
Also transmitted herewith is/are:
- ☐ Form PTO-1449 (PTO/SB/08A and 08B).
- ☐ Copies of citations listed.
- b. ☒ will be transmitted within THREE MONTHS of the date of submission of requirements under 35 U.S.C. § 371(c).
- c. ☐ was previously submitted by applicant on \_\_\_\_\_  
Date

13. ☐ An assignment document is transmitted herewith for recording.  
A separate ☐ "COVER SHEET FOR ASSIGNMENT (DOCUMENT) ACCOMPANYING NEW PATENT APPLICATION" or ☐ FORM PTO 1595 is also attached.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

(Transmittal Letter to the United States Elected Office (EO/US) [13-18]—page 6 of 8)

09/700811

532 Rec'd PCT/TO 20 NOV 2000

(Rel.82A—12/99 Pub.605)

FORM 13-18

13-165

14. ☒ Additional documents:

- a. ☐ Copy of request (PCT/RO/101)
- b. ☒ International Publication No. WO 99/61265
- i. ☒ Specification, claims and drawing
- ii. ☐ Front page only
- c. ☒ Preliminary amendment (37 C.F.R. § 1.121)
- d. ☒ Other

Small Entity StatementWritten OpinionApplicant's response to Written Opinion15. ☒ The above checked items are being transmitted

- a. ☒ before 30 months from any claimed priority date.
- b. ☐ after 30 months.

16. ☐ Certain requirements under 35 U.S.C. § 371 were previously submitted by the applicant on \_\_\_\_\_, namely:

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**AUTHORIZATION TO CHARGE ADDITIONAL FEES**

**WARNING:** Accurately count claims, especially multiple dependant claims, to avoid unexpected high charges if extra claims are authorized.

**NOTE:** "A written request may be submitted in an application that is an authorization to treat any concurrent or future reply, requiring a petition for an extension of time under this paragraph for its timely submission, as incorporating a petition for extension of time for the appropriate length of time. An authorization to charge all required fees, fees under § 1.17, or all required extension of time fees will be treated as a constructive petition for an extension of time in any concurrent or future reply requiring a petition for an extension of time under this paragraph for its timely submission. Submission of the fee set forth in § 1.17(a) will also be treated as a constructive petition for an extension of time in any concurrent reply requiring a petition for an extension of time under this paragraph for its timely submission." 37 C.F.R. § 1.136(a)(3).

**NOTE:** "Amounts of twenty-five dollars or less will not be returned unless specifically requested within a reasonable time, nor will the payer be notified of such amounts; amounts over twenty-five dollars may be returned by check or, if requested, by credit to a deposit account." 37 C.F.R. § 1.26(a).

- ☒ The Commissioner is hereby authorized to charge the following additional fees that may be required by this paper and during the entire pendency of this application to Account No. 19-4972

- ☒ 37 C.F.R. § 1.492(a)(1), (2), (3), and (4) (filing fees)

**WARNING:** Because failure to pay the national fee within 30 months without extension (37 C.F.R. § 1.495(b)(2)) results in abandonment of the application, it would be best to always check the above box.

(Transmittal Letter to the United States Elected Office (EO/US) [13-18]—page 7 of 8)

☒ 37 C.F.R. § 1.492(b), (c) and (d) (presentation of extra claims)

NOTE: Because additional fees for excess or multiple dependent claims not paid or not paid on later presentation must only be paid or these claims cancelled by amendment prior to the expiration of the time period set for response by the PTO in any notice of fee deficiency (37 C.F.R. § 1.492(d)), it might be best not to authorize the PTO to charge additional claim fees, except possible when dealing with amendments after final action.

☒ 37 C.F.R. § 1.17 (application processing fees)

☒ 37 C.F.R. § 1.17(a)(1)-(5) (extension fees pursuant to § 1.136(a).

☐ 37 C.F.R. § 1.18 (issue fee at or before mailing of Notice of Allowance, pursuant to 37 C.F.R. § 1.311(b))

NOTE: Where an authorization to charge the issue fee to a deposit account has been filed before the mailing of a Notice of Allowance, the issue fee will be automatically charged to the deposit account at the time of mailing the notice of allowance. 37 C.F.R. § 1.311(b).

NOTE: 37 C.F.R. § 1.28(b) requires "Notification of any change in loss of entitlement to small entity status must be filed in the application . . . prior to paying, or at the time of paying . . . issue fee." From the wording of 37 C.F.R. § 1.28(b): (a) notification of change of status must be made even if the fee is paid as "other than a small entity" and (b) no notification is required if the change is to another small entity.

☐ 37 C.F.R. § 1.492(e) and (f) (surcharge fees for filing the declaration and/or filing an English translation of an International Application later than 30 months after the priority date).

  
SIGNATURE OF PRACTITIONER

Timothy M. Murphy

(type or print name of practitioner)

Reg. No.: 33,198

Tel. No.: ( 617 ) 443-9292

Customer No.: 002101

P.O. Address



02101

PATENT TRADEMARK OFFICE

(Transmittal Letter to the United States Elected Office (EO/US) [13-18]—page 8 of 8)



**VERIFIED STATEMENT CLAIMING SMALL ENTITY STATUS -  
SMALL BUSINESS CONCERN**

Applicant: Leman  
International Appln No: PCT/GB99/01625  
U.S. Serial No: Not yet assigned  
International Filing Date: 21 May 1999  
U.S. Filing Date: Herewith  
For: A REMOTE TYRE PRESSURE MONITORING SYSTEM

I hereby declare that I am an official of the following small business concern and am empowered to act on its behalf:

Automotive Technologies Limited  
7 New Street  
P.O. Box 97  
St. Peter Port GY1 4BZ  
Germany

I hereby declare that the above-identified small business concern qualifies as a small business concern as defined in 13 CFR 121.3-18, and reproduced in 37 CFR 1.9(d), for purposes of paying reduced fees under Section 41(a) and (b) of Title 35, United States Code, in that the number of employees of the concern, including those of its affiliates, does not exceed 500 persons. For purposes of this statement, (1) the number of employees of the business concern is the average over the previous fiscal year of the concern of the persons employed on a full-time, part-time, or temporary basis during each of the pay periods of the fiscal year, and (2) concerns are affiliates of each other when either, directly or indirectly, one concern controls or has the power to control the other, or a third-party or parties controls or has the power to control both.

I hereby declare that rights under contract or law have been conveyed to, and remain with, the small business concern identified above with regard to the above-referenced invention.

If the rights held by the above-identified small business concern are not exclusive, each individual, concern, or organization having rights to the invention is listed below and no rights to the invention are held by any person, other than the inventor(s), who would not qualify as an independent inventor under 37 CFR 1.9(c) if that person made the invention, or by any concern

which would not qualify as a small business concern under 37 CFR 1.9(d) or a nonprofit organization under 37 CFR 1.9(c).

I acknowledge the duty to file, in this application, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small business entity is no longer appropriate.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

Name of person signing:

RICHARD J LEMAN

Title of person signing:

TECHNICAL CONSULTANT

Address of person signing:

R.V.L UNIT 1 CRUNDALLS

Signature:

G. J. Lemman

Date:

15 November 2000

02497/00001 136/05.1

GEORGE HILL  
MATFIELD  
KENT  
TN127GA.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Leman, R.

Att'y Docket: 2497/101

Int'l. Appln. No: PCT/GB99/01625

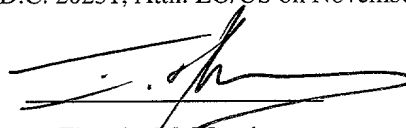
Int'l. Filing Date: May 21, 1999

Invention: A Remote Tire Pressure Monitoring System

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CERTIFICATE OF MAILING

I hereby certify that the following document is being transmitted via Express Mail **EL543501232US** to the Commissioner for Patents, Box PCT, Washington, D.C. 20231, Attn: EO/US on November 20, 2000.



Timothy M. Murphy

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Commissioner for Patents  
Box PCT  
Washington, D.C. 20231  
Attn: EO/US

PRELIMINARY AMENDMENT

Dear Sir:

The applicants submit this preliminary amendment in connection with entering the national phase for the above-referenced international patent application. Please enter the following amendment to the national stage application.

In the Abstract

Please substitute the abstract attached herein in place of the abstract contained in the application.

### In the Description

Please change, on page 1, in line 1, the word "TYRE" to --TIRE-- .

Please change, on page 1, in line 4, the word "tyres" to --tires--.

Please change, on page 1, in line 5, the word "tyre" to --tire--.

Please change, on page 1, in line 6, the word "tyre" to --tire--.

Please change, on page 1, in line 8, the word "tyres" to --tires--.

Please change, on page 1, in line 11, the word "tyre" to --tire--.

Please change, on page 1, in line 12, the word "tyre" to --tire--.

Please change, on page 1, in line 13, the word "tyre's" to --tire's--.

Please change, on page 1, in line 14, the word "tyre" to --tire--.

Please change, on page 1, in line 15, the word "tyre" to --tire--.

Please change, on page 1, in line 16, the word "tyre" to --tire--.

Please change, on page 1, in line 17, the word "tyre" to --tire--.

Please change, on page 1, in line 18, the word "tyre" to --tire--.

Please change, on page 1, in line 22, the word "tyre" to --tire--.

Please change, on page 1, in line 14, the words "of a tyre and providing a tyre" to --of a tire and providing a tire--.

Please change, on page 2, in line 3, the word "tyre" to --tire--.

Please change, on page 2, in line 5, the words "the tyre pressure sensor" to --the tire pressure sensor--.

Please change, on page 2, in line 5, the words "to measure the tyre" to --to measure the tire--.

Please change, on page 2, in line 6, the word "tyre" to --tire--.

Please change, on page 2, in line 9, the word "tyre" to --tire--.

Please change, on page 2, in line 11, the word "tyre" to --tire--.

Please change, on page 2, in line 13, the word "tyre" to --tire--.

Please change, on page 2, in line 14, the word "tyre" to --tire--.

Please change, on page 2, in line 16, the word "tyre" to --tire--.

Please change, on page 2, in line 23, the word "tyre" to --tire--.

Please change, on page 3, in line 8, the word "tyre" to --tire--.

Please change, on page 4, in line 2, the word "tyre" to --tire--.

Please change, on page 4, in line 4, the word "tyre" to --tire--.

Please change, on page 4, in line 7, the word "tyre" to --tire--.

Please change, on page 4, in line 8, the word "tyre" to --tire--.

Please change, on page 4, in line 10, the word "tyre" to --tire--.

Please change, on page 4, in line 11, the word "tyre" to --tire--.

Please change, on page 4, in line 14, the word "tyre" to --tire--.

Please change, on page 4, in line 16, the word "tyres" to --tires--.

Please change, on page 4, in line 20, the words "tyre pressure" to --tire pressure--.

Please change, on page 4, in line 20, the word "remote tyre" to --remote tire--.

Please change, on page 4, in line 21, the word "tyres" to --tires--.

Please change, on page 4, in line 22, the word "tyre" to --tire--.

Please change, on page 5, in line 2, the word "tyre" to --tire--.

Please change, on page 5, in line 4, the word "tyres" to --tires--.

Please change, on page 5, in line 7, the word "tyre" to --tire--.

Please change, on page 5, in line 13, the word "tyre" to --tire--.

Please change, on page 5, in line 13, the word "tyres" to --tires--.

Please change, on page 5, in line 15, the word "tyre" to --tire--.

Please change, on page 5, in line 20, the word "tyres" to --tires--.

Please change, on page 5, in line 23, the word "tyre" to --tire--.

Please change, on page 6, in line 1, the words "remote tyre" to --remote tire--.

Please change, on page 6, in line 1, the words "tyre sensors" to --tire sensors--.

Please change, on page 6, in line 7, the word "tyre" to --tire--.

Please change, on page 6, in line 8, the word "tyre" to --tire--.

Please change, on page 6, in line 9, the word "tyres" to --tires--.

Please change, on page 6, in line 10, the words "the tyre" to --the tire--.

Please change, on page 6, in line 10, the words "on tyre" to --on tire--.

Please change, on page 6, in line 11, the word "tyre" to --tire--.

Please change, on page 7, in line 6, the word "tyre" to --tire--.

Please change, on page 7, in line 14, the words "a tyre" to --a tire--.

Please change, on page 7, in line 14, the words "the tyre" to --the tire--.

Please change, on page 7, in line 17, the word "tyre" to --tire--.

Please change, on page 7, in line 18, the word "tyre" to --tire--.

Please change, on page 7, in line 20, the word "tyre" to --tire--.

Please change, on page 7, in line 22, the word "tyre" to --tire--.

Please change, on page 7, in line 24, the word "tyre" to --tire--.

Please change, on page 7, in line 17, the word "tyre" to --tire--.

Please change, on page 8, in line 3, the word "tyre" to --tire--.

Please change, on page 8, in line 5, the word "tyre" to --tire--.

Please change, on page 8, in line 7, the word "tyre" to --tire--.

Please change, on page 8, in line 11, the word "tyre" to --tire--.

Please change, on page 8, in line 12, the word "tyres" to --tires--.

Please change, on page 8, in line 14, the word "tyre" to --tire--.

Please change, on page 8, in line 16, the word "tyre" to --tire--.

Please change, on page 8, in line 20, the word "tyre" to --tire--.

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Please change, on page 8, in line 24, the word "tyres" to --tires--.

Please change, on page 9, in line 2, the word "tyres" to --tires--.

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Please change, on page 9, in line 6, the word "tyre" to --tire--.

Please change, on page 9, in line 13, the word "tyre" to --tire--.

Please change, on page 9, in line 17, the word "tyre" to --tire--.

Please change, on page 9, in line 20, the word "tyre" to --tire--.

Please change, on page 10, in line 6, the words "tyre - the tyre" to --tire - the tire--.

Please change, on page 10, in line 16, the word "tyre" to --tire--.

Please change, on page 11, in line 8, the word "tyre" to --tire--.

Please change, on page 11, in line 16, the word "tyre" to --tire--.

Please change, on page 12, in line 6, the word "tyre" to --tire--.

Please change, on page 12, in line 7, the word "tyre" to --tire--.

Please change, on page 12, in line 8, the word "tyre" to --tire--.

Please change, on page 12, in line 10, the word "tyre" to --tire--.

Please change, on page 18, in line 6, the word "tyre" to --tire--.

Please change, on page 18, in line 7, the word "tyres" to --tires--.

Please change, on page 18, in line 10, the word "tyre" to --tire--.

Please change, on page 18, in line 11, the word "tyre" to --tire--.

Please change, on page 19, in line 9, the word "tyre" to --tire--.

Please change, on page 21, in line 7, the word "tyre" to --tire--.

Please change, on page 21, in line 8, the word "tyre" to --tire--.

Please change, on page 21, in line 10, the word "tyre" to --tire--.

Please change, on page 21, in line 11, the word "tyres" to --tires--.

Please change, on page 21, in line 14, the word "tyres" to --tires--.

### In the Claims

Please amend claims 1-11, 13-16, and 19. Claims 12, 17, and 18 have been provided for completeness.

1. (Amended) A battery-powered [tyre] tire pressure sensor, comprising:  
a pressure transducer for sensing a pressure of a [tyre] tire and providing a [tyre] tire pressure signal;  
a transmitter;  
a signal processor connected to the pressure transducer for providing a signal dependent on the [tyre] tire pressure signal to the transmitter; and  
a timing circuit connected to the signal processor which is configured to automatically switch the [tyre] tire pressure sensor on periodically for a predetermined interval to measure the [tyre] tire pressure and switch off the [tyre] tire pressure sensor at all other times to conserve battery power in which the timing circuit comprises a timer and a switch, the timer being configured to periodically



actuate the switch and thereby connect the pressure sensor to the battery to turn the [tyre] tire pressure sensor on for said predetermined interval.

2. (Amended) A battery-powered [tyre] tire pressure sensor according to claim 1, further comprising a non-volatile memory device for storing an identification code used to identify transmissions from the pressure sensor.

3. A battery-powered [tyre] tire pressure sensor according to claim 2, in which the non-volatile memory device also stores calibration information which is used to determine the [tyre] tire pressure.

4. (Amended) A battery-powered [tyre] tire pressure sensor according to [any preceding] claim 1, further comprising a temperature transducer connected to the signal processor to provide a temperature signal to the signal processor, wherein the signal processor is adapted to apply a temperature compensation to the [tyre] tire pressure signal in dependence on the temperature signal.

5. (Amended) A battery-powered [tyre] tire pressure sensor according to [any preceding] claim 1, in which the signal processor is a microcontroller having an embedded computer program for controlling the operation of the pressure sensor.

6. (Amended) A battery-powered [tyre] tire pressure sensor according to claim 5, in which the microcontroller is configured to record battery voltage and operating temperature each time it makes a pressure measurement and, when necessary, encode this information together with the pressure sensor identification code for transmission via the transmitter.

7. (Amended) A battery-powered [tyre] tire pressure sensor according to [any preceding] claim 1, in which the transmitter comprises a surface acoustic wave (SAW) resonator.

8. (Amended) A battery-powered [tyre] tire pressure sensor according to [any preceding] claim 1, configured so that it does not make any transmissions until it is connected to an inflated [tyre] tire.

9. (Amended) A battery-powered [tyre] tire pressure sensor according to [any preceding] claim 1, adapted to be screwed onto the valve stem of a vehicle [tyre] tire.

10. (Amended) A remote [tyre] tire pressure monitoring system for mounting on a vehicle, comprising a plurality of [tyre] tire pressure sensors according to [any preceding] claim 1 in combination with a cab unit for mounting within the vehicle cab, the cab unit comprising:  
a receiver for detecting transmissions from the respective transmitters of the [tyre] tire pressure sensors; and,  
a display for providing a driver with information about the [tyres] tires on the vehicles in dependence on the received transmissions from the pressure sensors.

11. (Amended) A transponder unit for use in a remote [tyre] tire pressure monitoring system for a vehicle which includes a plurality of remote [tyre] tire pressure sensors connected to respective [tyres] tires, wherein each pressure sensor is adapted to transmit a signal with information about the condition of its respective [tyre] tire, the transponder unit comprising:  
a receiver for receiving the transmitted signals from the individual pressure sensors;

a signal processor for processing signals from the pressure sensors and generating a coded signal for transmission which identifies the transponder unit and [tyre] tire location; and,  
a transmitter for transmitting the coded signal to a remote receiver where information can be displayed to a driver about the [tyres] tires associated with the transponder unit.

12. A transponder unit according to claim 11, further comprising a memory to store a unique identification code to identify the transponder unit.

13. (Amended) A remote [tyre] tire pressure monitoring system comprising a transponder unit according to claim 11 [or 12], in combination with a cab unit, the cab unit comprising:  
a receiver for receiving the coded signal from the transponder unit;  
a signal processor for detecting and decoding the coded signal; and,  
a display for providing the driver with information about the condition of the [tyres] tires associated with the transponder unit.

14. (Amended) A remote [tyre] tire pressure monitoring system according to claim 13, further comprising a vehicle trailer on which the transponder unit is mounted.

15. (Amended) A remote [tyre] tire pressure monitoring system according to claim 13 [or 14], in which the remote [tyre] tire pressure sensors are battery-powered [tyre] tire pressure sensors [according to any of claims 1 to 9], each battery-powered tire pressure sensor comprising:  
a pressure transducer for sensing a pressure of a tire and providing a tire pressure signal;  
a transmitter;

a signal processor connected to the pressure transducer for providing a signal dependent on the tire pressure signal to the transmitter; and  
a timing circuit connected to the signal processor which is configured to automatically switch the tire pressure sensor on periodically for a predetermined interval to measure the tire pressure and switch off the tire pressure sensor at all other times to conserve battery power in which the timing circuit comprises a timer and a switch, the timer being configured to periodically actuate the switch and thereby connect the pressure sensor to the battery to turn the tire pressure sensor on for said predetermined interval.

16. (Amended) A vehicle comprising a cab unit and a trailer unit connectable to the cab unit, comprising a remote [tyre] tire pressure monitoring system according to [any of] claim[s] 13 [to 15].

17. A vehicle according to claim 16, in which the transponder unit is responsive to transmit an identification signal to the remote receiver when power is first supplied to the transponder unit.

18. A vehicle according to claim 17, in which power is supplied to the transponder unit by activation of the vehicle brake light line.

19. (Amended) A vehicle according to [any of] claim[s] 16 [to 18], wherein the receiver of the transponder unit has a processor programmed to recognise transmissions from sensors connected to wheels of the trailer and ignore all others.


In the Diagrams

Please accept the drawing change for FIG. 1 indicated in red on the attached copy of the informal drawing. The word "TYRE" has been changed to "TIRE." A copy of FIG. 1, with the change incorporated, is also enclosed. A Letter to the Master Draftsman accompanies this amendment with the correction to the drawing.

REMARKS

The foregoing amendment is intended to substitute American spellings for British spellings in the application and remove the multiple claims so as to place the claims in proper U.S. form. It is believed that the application is in condition for allowance.

Respectfully submitted,



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## ABSTRACT

### **A Remote Tire Pressure Monitoring System**

The present invention provides a battery-powered tire pressure sensor including a pressure transducer (10) for sensing a pressure of a tire and providing a tire pressure signal. The tire pressure sensor is arranged to transmit the signal containing information about the tire pressure of an associated vehicle tire to a cab unit (1) via a transmitter (13) where it is displayed to a driver of the vehicle. The pressure sensor monitors the pressure of the tire and provides the vehicle driver with early warning of any deflation, thereby improving safety as well as reducing tire wear and improving fuel economy. A timer (19) is included to turn the tire pressure sensor off when it is not in use to conserve battery power.

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## A REMOTE TYRE PRESSURE MONITORING SYSTEM

### Field of the Invention

The present invention relates to a system for monitoring the pressure of tyres in a wheeled  
5 vehicle. In particular, the invention relates to a tyre pressure monitoring system employing  
individual battery-powered pressure sensors associated with each tyre for transmitting coded  
information to a receiver mounted within the vehicle to provide information about the  
condition of the tyres to a driver of the vehicle.

### 10 Background to the Invention

It is well known that for commercial vehicles even a small deviation from the correct tyre  
pressure can adversely affect tyre wear and substantially increase the fuel consumption of  
the vehicle. Constant under inflation can reduce a tyre's life by up to 50%. A worn  
commercial tyre which is in every other sense in good condition can usually be retreaded  
15 twice. However, once the tyre walls are damaged through under inflation this is not  
possible. Furthermore, the majority of "blow-outs", tyre shredding and vehicle fires are  
caused by tyre under inflation. As a result, many large vehicle fleet operators spend  
significant sums on checking tyre pressures regularly. Most of this would be rendered  
unnecessary by a reliable automatic pressure monitoring system.

20

### Summary of the Invention

According to a first aspect of the present invention, a battery-powered tyre pressure sensor  
comprises:

a pressure transducer for sensing a pressure of a tyre and providing a tyre pressure signal;

a transmitter:

a signal processor connected to the pressure transducer for providing a signal dependent on the tyre pressure signal to the transmitter:

a timing circuit connected to the signal processor which is configured to automatically switch  
5 the tyre pressure sensor on periodically for a predetermined interval to measure the tyre pressure and switch off the tyre pressure sensor at all other times to conserve battery power. in which the timing circuit comprises a timer and a switch, the timer being configured to periodically actuate the switch and thereby connect the pressure sensor to the battery to turn the tyre pressure sensor on for said predetermined interval.

10

The tyre pressure sensor of the present invention is suitable for all types of vehicles, but is especially suited for fitting to commercial vehicles such as buses, coaches, trucks, and lorries. The pressure sensor monitors the pressure of a tyre and gives the vehicle driver early warning of any deflation, thereby improving safety, as well as reducing tyre wear and  
15 improving fuel economy. An important aspect of the present invention is that the pressure sensor is only switched on periodically under the control of a timer to sample the tyre pressure. This feature allows battery power to be conserved and therefore effectively extend the life of the battery or otherwise allow a smaller battery to be used.

20 Preferably, the pressure sensor further comprises a non-volatile memory device for storing an identification code used to identify transmissions from the pressure sensor. Preferably, the non-volatile memory device also stores calibration information which is used to determine an accurate tyre pressure. In particular, during manufacture each pressure sensor may be tested at atmospheric pressure, maximum rated pressure, and at several points



between, and the results of the calibration routine stored in the non-volatile memory device as variables which characterize the response of the pressure sensor. The advantage of a non-volatile memory is that data is not lost when the pressure sensor is switched off in the interval between pressure measurements.

5

Preferably, the sensor unit further comprises a temperature transducer connected to the signal processor to provide a temperature signal to the signal processor, wherein the signal processor is adapted to apply a temperature compensation to the tyre pressure signal in dependence on the temperature signal. This feature allows the signal processor to correct the output of the pressure transducer to ensure accuracy over a range of, for example,  $-40^{\circ}\text{C}$  to  $+60^{\circ}\text{C}$ . In addition, if the air temperature falls below say  $3^{\circ}\text{C}$ , this information can be transmitted by the pressure sensor to warn the vehicle driver that road conditions may be hazardous.

10

Preferably, the signal processor is a microcontroller having an embedded computer program for controlling the operation of the pressure sensor. Preferably, the microcontroller is configured to record battery voltage and operating temperature each time it makes a pressure measurement and, when necessary, encode this information together with the pressure sensor identification code for transmission via the transmitter.

20

Preferably, the transmitter comprises a surface acoustic wave (SAW) resonator. Suitable radio frequencies for use in the United Kingdom include 418 MHz and 433 MHz in accordance with the radio specifications for MPT 1340 of the Radio Communications Agency. These frequencies are currently licence exempt.

In a preferred example of the present invention, the pressure sensor is adapted to be screwed onto the valve stem of a vehicle tyre. This allows the pressure sensor to be retro-fitted to existing vehicles. As an alternative, the pressure sensor may be adapted for mounting within a vehicle tyre.

5

Preferably, the pressure sensor is configured so that it does not make any transmissions until it is connected to an inflated tyre. This feature ensures that battery power is conserved during transport and storage of the pressure sensor before fitting to a tyre.

10

According to a second aspect of the present invention, a remote tyre pressure monitoring system for mounting on a vehicle comprises a plurality of tyre pressure sensors according to the first aspect of the present invention in combination with a cab unit for mounting within the vehicle cab, the cab unit comprising:

a receiver for detecting transmissions from the respective transmitters of the tyre pressure sensors; and,

15

a display for providing a driver with information about the tyres on the vehicles in dependence on the received transmissions from the pressure sensors.

20

According to a third aspect of the present invention, a transponder unit for use in a remote tyre pressure monitoring system for a vehicle which includes a plurality of remote tyre pressure sensors connected to respective tyres, wherein each pressure sensor is adapted to transmit a signal with information about the condition of its respective tyre, the transponder unit comprising:

a receiver for receiving the transmitted signals from the individual pressure sensors:

a signal processor for processing signals from the pressure sensors and generating a coded signal for transmission which identifies the transponder unit and tyre location; and,

a transmitter for transmitting the coded signal to a remote receiver where information can be displayed to a driver about the tyres associated with the transponder unit.

5

The transponder unit of the present invention allows a cab unit within a vehicle cab to distinguish between transmissions from the remote tyre pressure sensors of a trailer and other pressure sensors without requiring the driver to individually register each pressure sensor of the trailer whenever the vehicle cab and trailer are first connected. This is useful since a lorry driver may change trailer frequently. The cab unit within the vehicle cab is able to "learn" the unique identifier for the trailer transponder unit so that it can recognise subsequent transmissions forwarded by the transponder unit which encode information from the tyre pressure sensors connected to the trailer tyres.

10

15 According to a fourth aspect of the present invention, a remote tyre pressure monitoring system comprises a transponder unit according to the third aspect of the present invention in combination with a cab unit, wherein the cab unit comprises:

a receiver for receiving the coded signal from the transponder unit;

a signal processor for detecting and decoding the coded signal; and,

20 a display for providing the driver with information about the condition of the tyres associated with the transponder unit.

Preferably, the remote tyre pressure monitoring system comprises a vehicle trailer on which the transponder unit is mounted.

Preferably, the remote tyre pressure sensors are tyre pressure sensors in accordance with the first aspect of the present invention.

The present invention combines simplicity of operation with the most advanced solid-state electronic design. It is proposed that the valve dust cap for each wheel of a vehicle is replaced by a pressure sensor in accordance with the present invention which monitors the tyre pressure and reports to a computer controlled unit in the vehicle cab. Should, for example, the pressure in any tyre drop by more than say 12.5%, a radio signal is then sent to a display in the cab to warn the driver as to which of his tyres is losing air. The driver then has time to act before the tyre is damaged, thereby saving on tyre wear and fuel, and perhaps avoiding the expensive results of complete tyre failure. It is also intended that the driver should be warned if any pressure sensor is suffering from low battery power or is missing or malfunctioning in any other way. Furthermore, if the air temperature at road level approaches freezing point the system warns of possible road icing. For articulated rigs, a radio transponder unit mounted on the front of the trailer relays messages from pressure sensors connected to the trailers wheels to the vehicle cab. With aerials and cabling supplied, the system of the present invention is as easy to fit as a car radio. In addition, there is nothing to connect or disconnect when changing trailer. The cab unit is pre-programmed to accept the new set of trailer wheels but will not respond to pressure sensors from other rigs.

An important aspect of the present invention is that the pressure sensors have a long life, typically up to three years. This is achieved by the use of the timing circuit which ensures that the pressure sensor is switched off most of the time. Typically, each pressure sensor

will draw a current of significantly less than 1  $\mu\text{A}$  between pressure measurements, and draw only a small current of the order of 4.5 mA when switched on.

The present invention will lead to significant savings in running costs for commercial vehicle operators; savings within the first year which should represent four times the purchase price. Added to this are the safety advantages, greater reliability, and reduced levels of tyre maintenance.

#### Brief Description of the Drawings

Examples of the present invention will now be described in detail with reference to the accompanying drawings, in which:

Figure 1 is a block diagram of a tyre pressure monitoring system according to the present invention:

Figure 2 is a block diagram of an example of a tyre pressure sensor for use in the tyre pressure monitoring system of Figure 1:

Figure 3 shows a circuit implementing a temperature transducer, a pressure transducer and a reference voltage generator for use in the tyre pressure sensor of Figure 2:

Figure 4 shows a timing circuit implementing a timer and switch for use in the tyre pressure sensor of Figure 2;

Figure 5 shows an example of a transmitter and antenna circuit for use in the tyre pressure sensor of Figure 2;

Figure 6 shows an example of a non-volatile memory device for use in the tyre pressure sensor of Figure 2;

Figure 7 shows an example of a microcontroller for use in the tyre pressure sensor of Figure

2:

Figure 8 is a flow chart showing the sequence of operations for a calibration routine;

Figure 9 is a flow chart showing the sequence of operations for a tyre pressure measurement routine;

5     Figures 10 and 11 show a cab unit for use in the tyre pressure monitoring system of Figure 1; and.

Figure 12 is a block diagram of a transponder unit for use in the tyre pressure monitoring system of Figure 1.

## 10     Detailed Description

Figure 1 shows an example of a tyre pressure monitoring system according to the present invention. The system is suitable for mounting on the tyres of a vehicle such as a truck, bus, or coach, and also on lorries which have a vehicle cab (tractor) and a separate trailer. As shown, the system includes a cab unit 1 and a first set of tyre pressure sensor units 2<sub>1</sub> to 2<sub>4</sub>. When applicable, the system includes a trailer transponder unit 3 and a second set of tyre pressure sensor units 4<sub>1</sub> to 4<sub>3</sub> associated with a trailer.

As will be described below, each of the sensor units 2<sub>1</sub> to 2<sub>4</sub> and 4<sub>1</sub> to 4<sub>3</sub> has a radio transmitter for transmitting a coded signal which carries information relating to the condition of a respective tyre to a receiver in the cab unit 1. The information is used to inform the vehicle driver about the pressure and temperature of each of the tyres by way of an audio/-visual display forming part of the cab unit 1. The transponder unit 3 is designed to be mounted on a lorry trailer and it detects transmitted signals from each of the second set of sensor units 4<sub>1</sub> to 4<sub>3</sub> associated with respective tyres of the trailer. The transponder

unit 3 transmits a coded signal to the cab unit 1 containing information about each of the trailer tyres. The cab unit 1 is adapted to decode the transponder signal and distinguish between the transponder signal and any other signal so that the driver can be alerted of any fault that has occurred in relation to any of the tyres on the lorry trailer as well as the cab.

.5

Figure 2 shows a schematic representation of an example of a battery-powered tyre pressure sensor in accordance with the present invention. The pressure sensor comprises a pressure transducer 10, a temperature transducer 11, a reference voltage generator 12, a transmitter 13 and a non-volatile memory device 14, all connected to a microcontroller 15. The device also houses a battery 16 as the power supply. The pressure sensor is periodically activated by a timing circuit 17. The timing circuit 17 comprises a switch 18 and a timer 19. The timer 19 is configured to cause the pressure sensor to sample periodically the pressure of the tyre to which the device is connected, but otherwise disconnect the other elements of the pressure sensor from the battery 16 at all other times to conserve battery power. Finally, a calibration switch 20 is provided to calibrate the pressure sensor before shipping, as will be described below. The pressure sensor is implemented on a printed circuit board and, together with the battery, sealed with a housing adapted to be screwed onto a tyre valve stem.

20 The pressure transducer 10 is arranged to measure the pressure of the tyre and provide an output (PRESSURE) to the microcontroller 15. A suitable device is a piezo-resistive sensor, the resistivity of which changes with changes in pressure. An example of a suitable circuit which implements a pressure transducer is shown in Figure 3.

10

The temperature transducer 11 is configured to measure the temperature of the air surrounding the sensor and provide an output (TEMP) to the microcontroller 15. This output signal is used to provide a temperature compensation to the pressure signal output from the pressure transducer 10 so that an accurate pressure reading can be derived for comparison with a reference value stored in the non-volatile memory device 14 (which is obtained when the pressure sensor is first connected to a tyre - the tyre having been previously correctly inflated). The temperature signal may also be used to provide a driver of the vehicle with information about related driving conditions. An example of a suitable circuit which implements a temperature sensor is shown in Figure 3.

10

The reference voltage generator 12 is configured to generate a stable reference voltage signal (VREF) which is provided as an input to the microcontroller 15. The microcontroller 15 compares the reference voltage with the battery voltage (VOLTS) and generates an output signal dependent on this comparison. If the battery voltage is less than the reference voltage this means that a new battery is required and a signal is generated to convey this to the driver. Furthermore, in this event, the frequency of the sampling of the tyre pressure may automatically be reduced to prolong the life of the battery until a new pressure sensor or battery can be fitted. An example of a suitable circuit which implements a reference voltage generator is shown in Figure 3.

20

As described above, the timing circuit 16 comprises a switch 18 and a timer 19. The timer 19 runs all the time and periodically engages the switch 18 to start a pressure measurement cycle. At all other times the remaining components of the pressure sensor are switched off to conserve battery power. Furthermore, as described above, the frequency at which the



pressure sensor is switched on is dependent on the battery voltage. When this starts to fall, the microcontroller 15 generates a warning message in the next routine status transmission and at the same time reduces the sensor sampling frequency to conserve the remaining battery life. An example of a suitable circuit which implements the timer and switch functions is shown in Figure 4. The battery 16 is a lithium device having a diameter of 16mm with a rating of typically 60-70 mAh.

The function of the radio transmitter 14 is to send messages from each tyre pressure sensor to a receiver in either the cab unit 1 of the vehicle cab or in the transponder unit 3 of a trailer. For the United Kingdom, it is proposed that the transmitter 14 transmits the signal generated by the microprocessor 15 at a frequency of either 418 MHz or 433 MHz in accordance with the MPT1 340 specification. These frequencies are currently licence exempt. A suitable type of transmitter 15 is based on a surface acoustic wave (SAW) device. An example of a suitable circuit can be seen in Figure 5.

The non-volatile memory 15 stores information about the tyre and also contains a unique pressure sensor identification code, programmed during manufacture as part of a calibration process, as will be described below. One advantage of having a non-volatile memory device 15 in the pressure sensor is that when the sensor unit is switched off information is not lost. This is important since it enables power to be completely shut down to the main components of pressure sensor in the interval between sensor readings. An example of a suitable memory device is shown in Figure 6.

The microcontroller 15 accepts a signal from each of the pressure transducer 10, the

temperature transducer 11 and the reference voltage generator 12. It processes these signals and provides an output signal to the transmitter 14 which includes the unique sensor identification code for the pressure sensor. An example of a suitable microcontroller is shown in Figure 7. Each time the microcontroller 15 receives a signal from the pressure transducer 10 it also records the battery voltage and temperature. Thus, with the appropriate programming, it is able to determine an accurate pressure measurement for the tyre. The tyre pressure measurement is compared with a stored (notionally correct) reference value and if the tyre pressure is determined to deviate from this by a predetermined amount a message is generated by the microcontroller 15 for transmission. In addition to, or even in the absence of, any message relating to the condition of the tyre or driving conditions, the microcontroller 15 is arranged periodically to generate an identification message for transmission which serves to confirm that the pressure sensor remains operational. Failure to transmit such a message will eventually cause a warning to be displayed on the cab unit 1 to indicate to the driver that the pressure sensor has either failed or been removed.

15 A computer program is embedded within the microcontroller 15 which controls the operation of the pressure sensor. The computer program is executed when power is applied to the microcontroller 15 by the timing circuit 16, initiated by the timer 19. The computer program contains two distinct parts. One part executes during a calibration cycle and the other part executes at all other times. The microcontroller 15 decides which part to execute by examining the state of the MODE input pin (pin 7 in Figure 7). As shown in the pseudocode below and the flow chart of Figure 8, during calibration the MODE pin is initially set to a low state by a calibration jig (not shown). At all other times it is kept in a high state. Once calibration commences the MODE pin is used as a bi-directional path

for signals between the microcontroller 15 and the calibration jig.

#### START of PROGRAM

Carry out system initialising tasks

5 Read the status of the MODE pin

IF MODE pin is in low state THEN

Execute Calibrate\_Code

ELSE

10 Execute Normal\_Code

ENDIF

The pseudocode below and flow chart of Figure 8 detail the calibration procedure for a pressure sensor:

15

#### Calibrate\_Code

Wait for the MODE pin to signal that the calibration jig has stabilised the pressure at a low reference value. Provide a high excitation voltage to the pressure transducer, via OUTB of the D-A converter of the pressure transducer 10 (Figure 3). Adjust OUTA of the D-A converter to provide zero output between the pressure transducer outputs (OUT+ and OUT-).

20

Store the digital value required to achieve the zero output in the Non-Volatile Memory (Step XX).

Wait for the MODE pin to signal that the calibration jig has stabilised the pressure at the high reference value.

Adjust OUTA of the D-A converter to provide a standard output between the pressure  
5 transducer outputs (OUT+ and OUT-).

Store the digital value required to achieve the standard output in the Non-Volatile Memory (Step YY).

10 Wait for the MODE pin to signal that the calibration jig has stabilised the pressure at one of several intermediate pressure reference values. For each pressure step:

Using the calibration coefficients stored in Non-Volatile memory (Steps XX and YY above) calculate the expected pressure transducer output; and.

Measure the output of the pressure transducer and compare it with the calculated  
15 value.

Set a flag bit in memory to indicate agreement between the measured and calculated values.

The MODE pin is driven by the calibration jig (not shown) which provides manufacturing  
20 date code, the identification code for the unit, an initial reference pressure of zero, multi-count value, percentage pressure band limits, battery condition flag and other information that may be required to be stored. This data is routed to and stored in the non-volatile memory.

The pseudo code below and flow chart of Figure 9 details the normal operation of the pressure sensor:

#### Normal\_Code

5 Recover the value of the Reference Pressure from the Non-Volatile Memory.

IF the stored Reference Pressure is zero THEN

Recover the pressure calibration coefficients from the Non-Volatile Memory.

Read the temperature transducer to determine the current temperature.

Read the current pressure and apply temperature corrections.

10 IF the corrected current pressure is less than a small figure (typically 2 PSI) THEN

Do nothing

ELSE

Write the current pressure into a Reference Pressure location in the Non-Volatile Memory.

15 Recover the unit identification code from the Non-Volatile Memory.

Transmit the sensor identification code to the Cab Unit via the transmitter and antenna together with a message indicating that this is an initial transmission from the particular sensor. Repeat the transmission several times to increase the probability of correct reception by the Cab Unit.

20 ENDIF

Disable the Power Switch (Sleep)

ELSE

Recover the multi-count value from Non-Volatile Memory

IF the multi-count is not zero THEN

16

Recover the current cycle-counter value

IF the value of the cycle-counter is not zero THEN

Decrement the cycle-counter value

Write the cycle-counter value back into Non-Volatile Memory

5                   Disable the Power Switch (Sleep)

ENDIF

ENDIF

ENDIF

Recover the battery low flag from Non-Volatile memory

10 IF the battery low flag indicates a healthy battery THEN

Write the multi-count value into Non-Volatile Memory to initialise a new count down sequence.

ELSE

Write an increased multi-count value into Non-Volatile Memory to initialise a new  
15 larger (battery conserving) count down cycle.

ENDIF

Recover the calibration coefficients from the Non-Volatile Memory.

Send the calibration coefficients to the D-A converter where they will be converted to voltages at OUTA and OUTB.

20

Read the temperature transducer to ascertain the current temperature.

Set the temperature warning flag if the temperature is low enough to merit warning the driver that road conditions are becoming hazardous.

Read the current output from the pressure transducer circuit and apply temperature

corrections.

Recover the acceptable percentage band limits from the Non-Volatile Memory.

Compare the reference pressure with the pressure reading that has just been taken and  
5 corrected for temperature effects.

IF pressure is outside acceptable percentage limits THEN

Set a flag Pressure Warning flag

ENDIF

Determine the battery voltage using the voltage reference and potential divider.

10 Determine if the voltage is above a threshold that indicates a healthy battery.

IF the battery voltage check indicates that the battery is beginning to fail THEN

Set a battery-low flag into Non Volatile Memory.

ENDIF

Compose a message containing the sensor identification code, the result of the pressure  
15 check, the temperature flag and the battery condition.

Transmit the message to the Cab Unit via the transmitter and antenna together with a header  
indicating that this is a routine transmission.

IF the pressure reading was outside the acceptable percentage band limits THEN

20 Repeat the transmission several times to increase the probability of reception.

IF the pressure reading was zero THEN

Set the reference pressure stored in the Non-Volatile Memory to zero.

ENDIF

ENDIF

### Disable the Power Switch (Sleep)

Figure 10 shows a schematic representation of an example of a cab unit 1 suitable for use in the tyre pressure monitoring system. The cab unit 1 comprises a receiving antenna 30, a microcontroller 31, a driver's display 32 to display information about the tyres to the driver, and a memory 33. The microcontroller 31 is able to distinguish between signals and identify, by way of its unique identification code, which pressure sensor or transponder unit is sending each signal. In normal operation, each pressure sensor periodically transmits an "all's-well" signal. If the cab unit 1 detects two consecutive missing signals from the same unit, an LED will flash to tell the driver to check that tyre. The cab unit 1 can display warnings whenever any tyre is suffering from any of low pressure, low temperature, low battery or a missing sensor unit. The drivers cab display 32 is shown in detail in Figure 11.

The drivers cab display 32 has the following items:

- 15 - a two digit wheel number indicator 40 with two small adjacent LED indicators. One LED illuminates when the wheel number displayed relates to the cab and the other illuminates when the wheel number relates to a trailer;
- further LEDs 41 to 44 provide "low temperature", "low pressure", "low battery", and "unit missing" warnings, respectively; and,
- 20 - a switch 45 with positions, LEARN CAB, LEARN TRAILER and NORMAL, with small LEDs to indicate a teaching process (to be described below) is being carried out.

An acoustic sounder (not shown) is included in the cab unit 1 and sounds for ten seconds



after a warning message is received and every five minutes thereafter. When the ignition is turned on the sounder makes a short chirp. If a warning message has been received during driver absence it will sound for ten seconds. Power is supplied continuously by the vehicle battery or via the ignition circuit. A "cancel" button (not shown) is also provided which can disable a warning entry until the next ignition off-on cycle.

Figure 12 shows a schematic representation of an example of a transponder unit 3 for a trailer. The transponder unit comprises a receiver 51, a microcontroller 52 and a transmitter 53. The receiver 51 periodically receives signals transmitted by individual tyre pressure sensors and couples the signals to the microcontroller 52. The microcontroller 52 processes a signal and generates a new message which incorporates a unique identification code associated with the transponder unit 3 as a header which is transmitted by the transmitter 53 and which can be detected by the cab unit. This identification code, as with the pressure sensors, is stored in a memory 54.

Referring to Figure 11 above, when fitting pressure sensors to a single vehicle or a cab, the driver selects the LEARN feature to indicate that pressure sensors are about to be installed on the wheels. The cab unit 1 then wipes out all stored information (if any) relating to previous wheels. The driver then walks around the vehicle fitting pressure sensors to each of the valves of the wheels in a predetermined order. Once fitted, a pressure sensor recognises it has lifted off from 0 psi and sends its identification code several times. After each pressure sensor is fitted the driver must wait for the cab unit 1 to sound to indicate that it has recognised the new sensor unit successfully before proceeding to the next wheel. After all the wheels have been fitted with a pressure sensor, the driver then selects the

NORMAL feature. At this stage the cab unit 1 now knows how many wheels are present and their identification codes. and the monitoring system is then ready for use.

When fitting pressure sensors to a trailer, the driver selects a corresponding LEARN  
5 TRAILER feature on the trailer transponder unit 3 (not shown). The driver then walks around the trailer in the same manner as for a cab unit, fitting each of the wheels in turn with a pressure sensor so that the trailer transponder unit 3 knows how many wheels are present and their identification codes. When the trailer is then connected to the vehicle cab, the driver selects the LEARN TRAILER feature on the cab unit 1 so that any previous  
10 information relating to trailers is deleted. After the ignition is turned on, when the brake pedal is first depressed the trailer transponder unit 3 recognises that it should identify itself to the cab unit 1 because this is the first time it has had power supplied and the brake light line is active. It then transmits its unique identification code to the cab unit 1 to identify itself as a new trailer. This identification code for the trailer is then stored in the cab unit  
15 1. The driver subsequently selects the NORMAL feature and the system is now ready for use.

As an alternative, the "learn trailer" step can be automated so that the driver does not even need to select this on the cab unit - the registration process is carried out automatically after  
20 ignition is switched on.

The cab unit 1 receives transmissions from the cab's wheels, which are recognised, and trailer wheel messages which are ignored. The trailer transponder unit 3 receives transmission from its own wheels, which are recognised, and the cab wheels which are

ignored. As described above, information from the trailer wheels is stored in the trailer transponder unit 3 and warning and other messages from the trailer transponder unit 3 are relayed to the cab with a message header so that they are recognised by the cab. It is proposed that warning messages are passed to the cab immediately by the transponder unit  
5 3 whereas routine "all's well" messages are only sent periodically.

It is possible to build on the tyre pressure monitoring system of the present invention to provide a complete tyre management system for a fleet operator. The idea is that as each vehicle returns to a depot, the cab unit is automatically interrogated to determine the  
10 condition of each tyre. The vehicle depot keeps a computer database which provides a record of the vehicle movements and a list of which tyres on which vehicles need attention. In this way, the need to rely on driver trip reports is reduced. The depot system could also be programmed to interrogate vehicles as they leave a depot as a double check that any defective tyres have been duly corrected.

## CLAIMS

1. A battery-powered tyre pressure sensor, comprising:  
a pressure transducer for sensing a pressure of a tyre and providing a tyre pressure signal:  
5 a transmitter:  
a signal processor connected to the pressure transducer for providing a signal dependent on the tyre pressure signal to the transmitter:  
a timing circuit connected to the signal processor which is configured to automatically switch the tyre pressure sensor on periodically for a predetermined interval to measure the tyre  
10 pressure and switch off the tyre pressure sensor at all other times to conserve battery power, in which the timing circuit comprises a timer and a switch, the timer being configured to periodically actuate the switch and thereby connect the pressure sensor to the battery to turn the tyre pressure sensor on for said predetermined interval.
- 15 2. A battery-powered tyre pressure sensor according to claim 1, further comprising a non-volatile memory device for storing an identification code used to identify transmissions from the pressure sensor.
3. A battery-powered tyre pressure sensor according to claim 2, in which the non-  
20 volatile memory device also stores calibration information which is used to determine the tyre pressure.
4. A battery-powered tyre pressure sensor according to any preceding claim, further comprising a temperature transducer connected to the signal processor to provide a

temperature signal to the signal processor, wherein the signal processor is adapted to apply a temperature compensation to the tyre pressure signal in dependence on the temperature signal.

5 5. A battery-powered tyre pressure sensor according to any preceding claim, in which the signal processor is a microcontroller having an embedded computer program for controlling the operation of the pressure sensor.

10 6. A battery-powered tyre pressure sensor according to claim 5, in which the microcontroller is configured to record battery voltage and operating temperature each time it makes a pressure measurement and, when necessary, encode this information together with the pressure sensor identification code for transmission via the transmitter.

15 7. A battery-powered tyre pressure sensor according to any preceding claim, in which the transmitter comprises a surface acoustic wave (SAW) resonator.

8. A battery-powered tyre pressure sensor according to any preceding claim, configured so that it does not make any transmissions until it is connected to an inflated tyre.

20 9. A battery-powered tyre pressure sensor according to any preceding claim, adapted to be screwed onto the valve stem of a vehicle tyre.

10. A remote tyre pressure monitoring system for mounting on a vehicle, comprising a plurality of tyre pressure sensors according to any preceding claim in combination with a

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cab unit for mounting within the vehicle cab, the cab unit comprising:

a receiver for detecting transmissions from the respective transmitters of the tyre pressure sensors; and,

a display for providing a driver with information about the tyres on the vehicles in dependence on the received transmissions from the pressure sensors.

11. A transponder unit for use in a remote tyre pressure monitoring system for a vehicle which includes a plurality of remote tyre pressure sensors connected to respective tyres, wherein each pressure sensor is adapted to transmit a signal with information about the condition of its respective tyre, the transponder unit comprising:

a receiver for receiving the transmitted signals from the individual pressure sensors;

a signal processor for processing signals from the pressure sensors and generating a coded signal for transmission which identifies the transponder unit and tyre location; and,

a transmitter for transmitting the coded signal to a remote receiver where information can be displayed to a driver about the tyres associated with the transponder unit.

12. A transponder unit according to claim 11, further comprising a memory to store a unique identification code to identify the transponder unit.

13. A remote tyre pressure monitoring system comprising a transponder unit according to claim 11 or 12, in combination with a cab unit, the cab unit comprising:

a receiver for receiving the coded signal from the transponder unit;

a signal processor for detecting and decoding the coded signal; and,

a display for providing the driver with information about the condition of the tyres associated with the transponder unit.

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14. A remote tyre pressure monitoring system according to claim 13, further comprising a vehicle trailer on which the transponder unit is mounted.

15. A remote type pressure monitoring system according to claim 13 or 14, in which the remote tyre pressure sensors are tyre pressure sensors according to any of claims 1 to 9.

16. A vehicle comprising a cab unit and a trailer unit connectable to the cab unit, comprising a remote tyre pressure monitoring system according to any of claims 13 to 15.

17. A vehicle according to claim 16, in which the transponder unit is responsive to transmit an identification signal to the remote receiver when power is first supplied to the transponder unit.

18. A vehicle according to claim 17, in which power is supplied to the transponder unit by activation of the vehicle brake light line.

19. A vehicle according to any of claims 16 to 18, wherein the receiver of the transponder unit has a processor programmed to recognise transmissions from sensors connected to wheels of the trailer and ignore all others.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Leman, R.

Att'y Docket: 2497/101

Int'l. Appln. No: PCT/GB99/01625

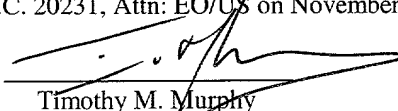
Int'l. Filing Date: May 21, 1999

Invention: A Remote Tire Pressure Monitoring System

\*\*\*\*\*

CERTIFICATE OF MAILING

I hereby certify that the following document is being transmitted via Express Mail **EL543501232US** to the Commissioner for Patents, Box PCT, Washington, D.C. 20231, Attn: EO/US on November 20, 2000.

  
Timothy M. Murphy

\*\*\*\*\*

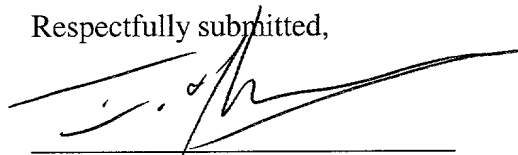
Commissioner for Patents  
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Washington, D.C. 20231  
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**LETTER TO MASTER DRAFTSMAN**

Dear Sir:

Please indicate acceptance of the enclosed changes marked in red ink on the drawing designated as Fig. 1. The word "TYRE" has been changed to "TIRE."

Respectfully submitted,



Date: November 20, 2000

Timothy M. Murphy  
Registration No. 33,198  
Attorney for Applicants

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Boston, MA 02110-1618  
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02947/00101 136048.1



FIG. 1

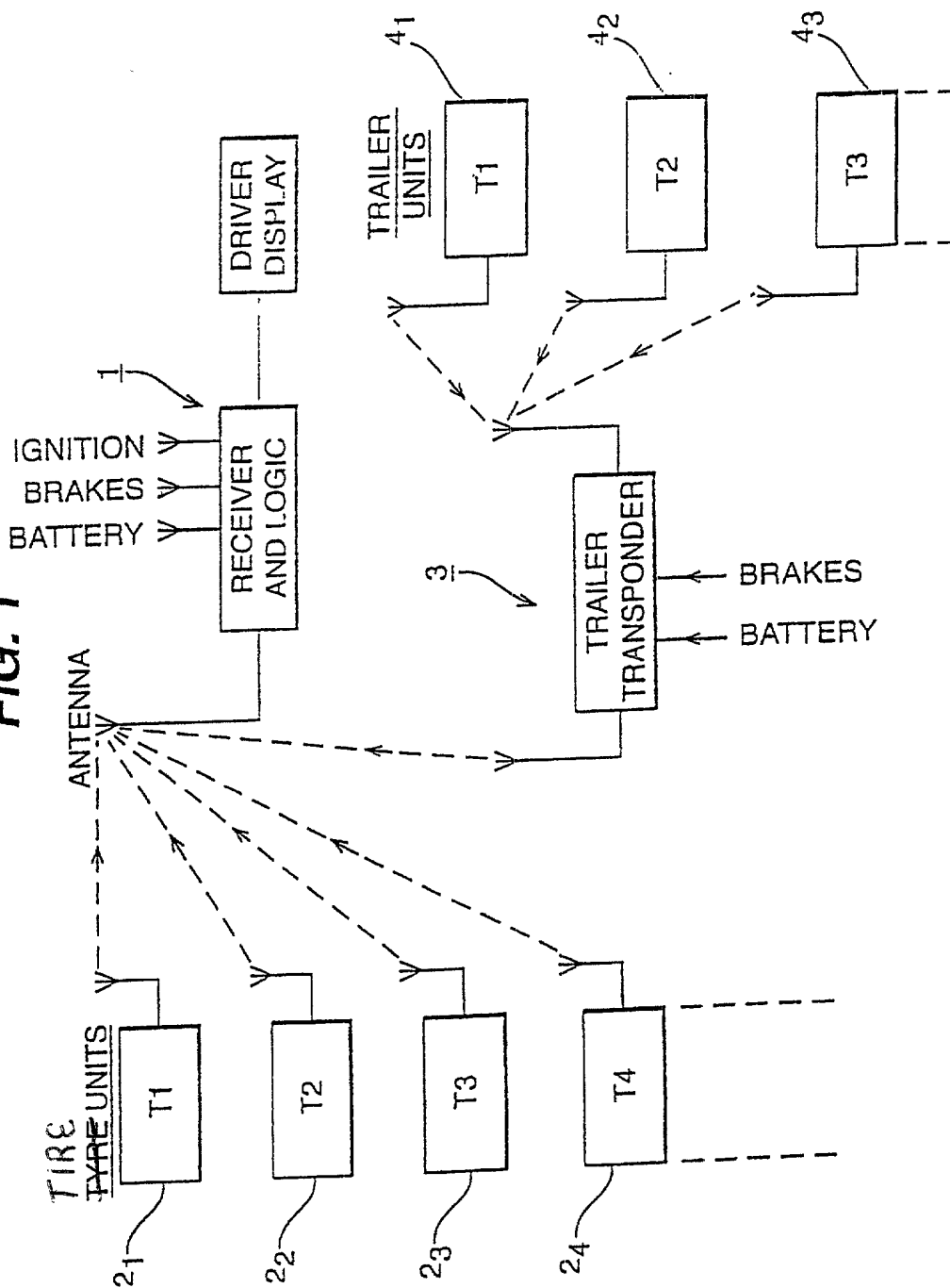
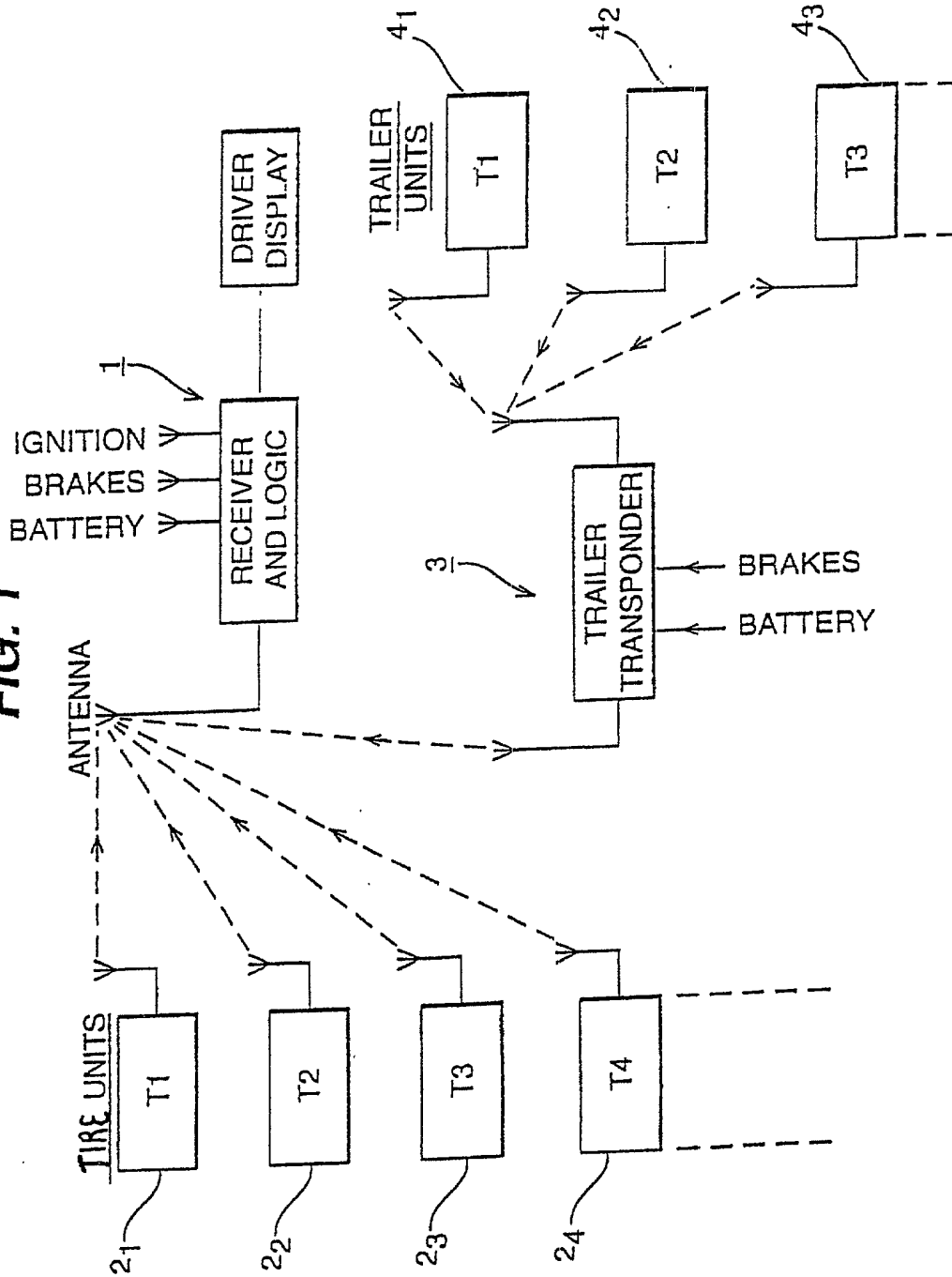
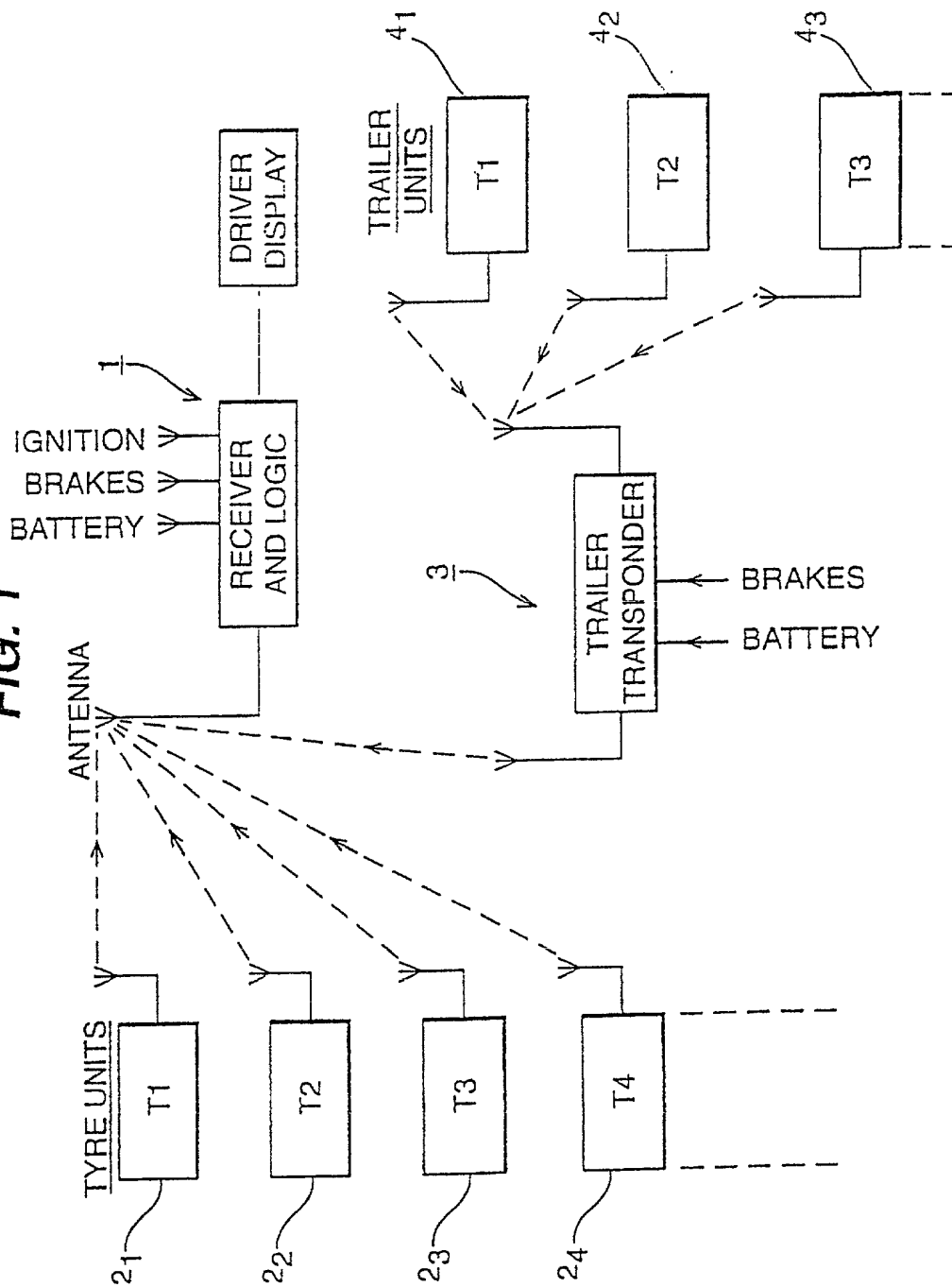
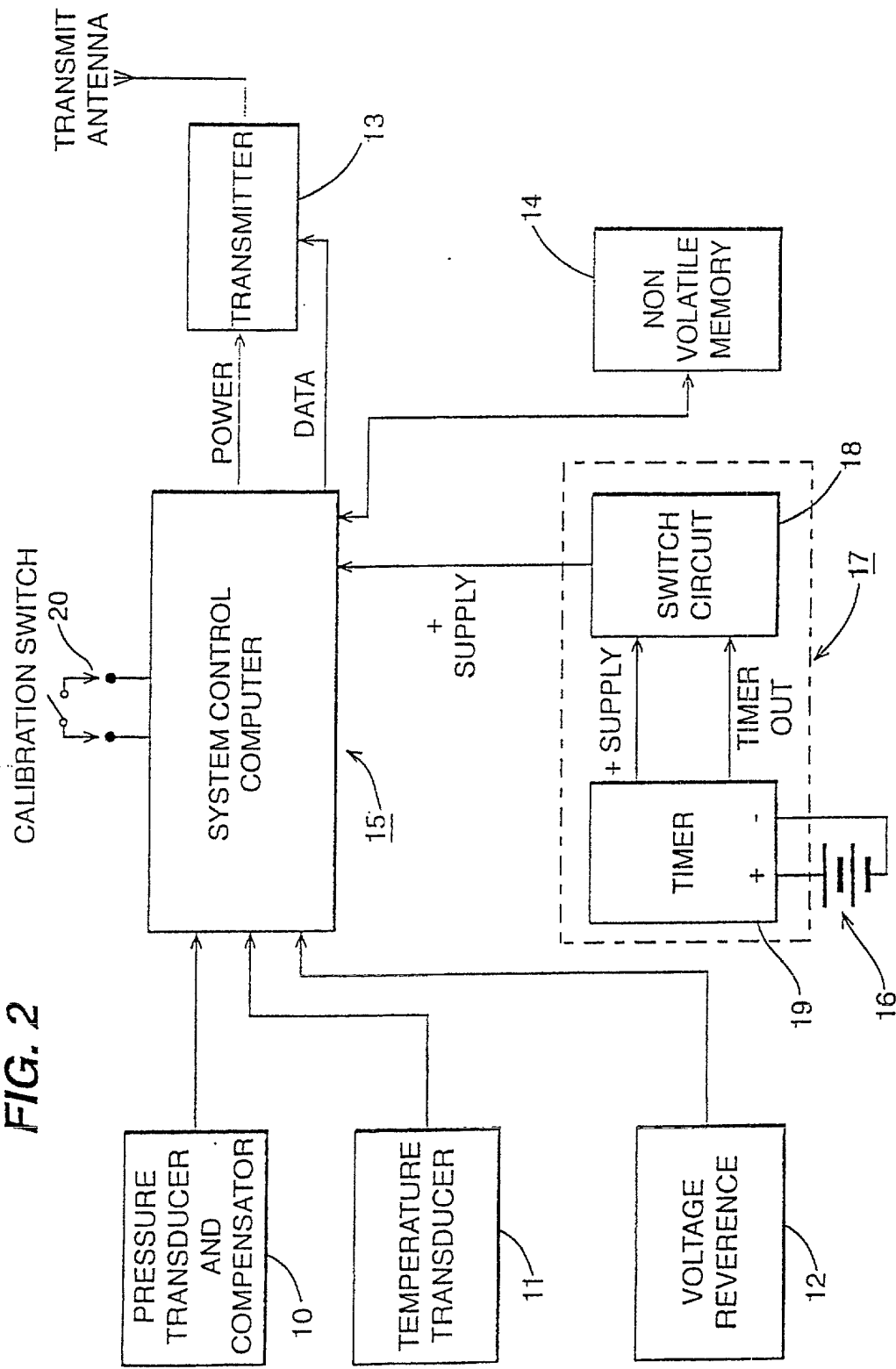


FIG. 1

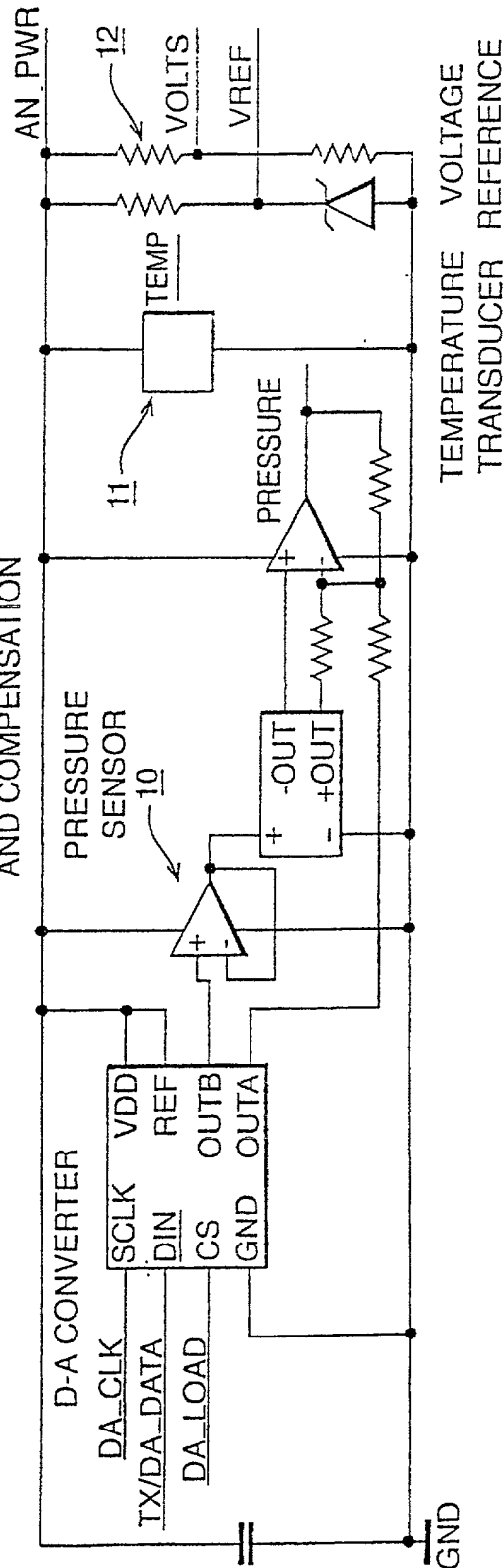


**FIG. 1**



**FIG. 3**

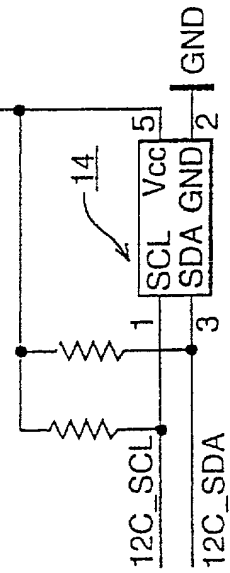
**PRESSURE TRANSDUCER  
AND COMPENSATION**



**FIG. 6**

**NON VOLATILE MEMORY**

VCC

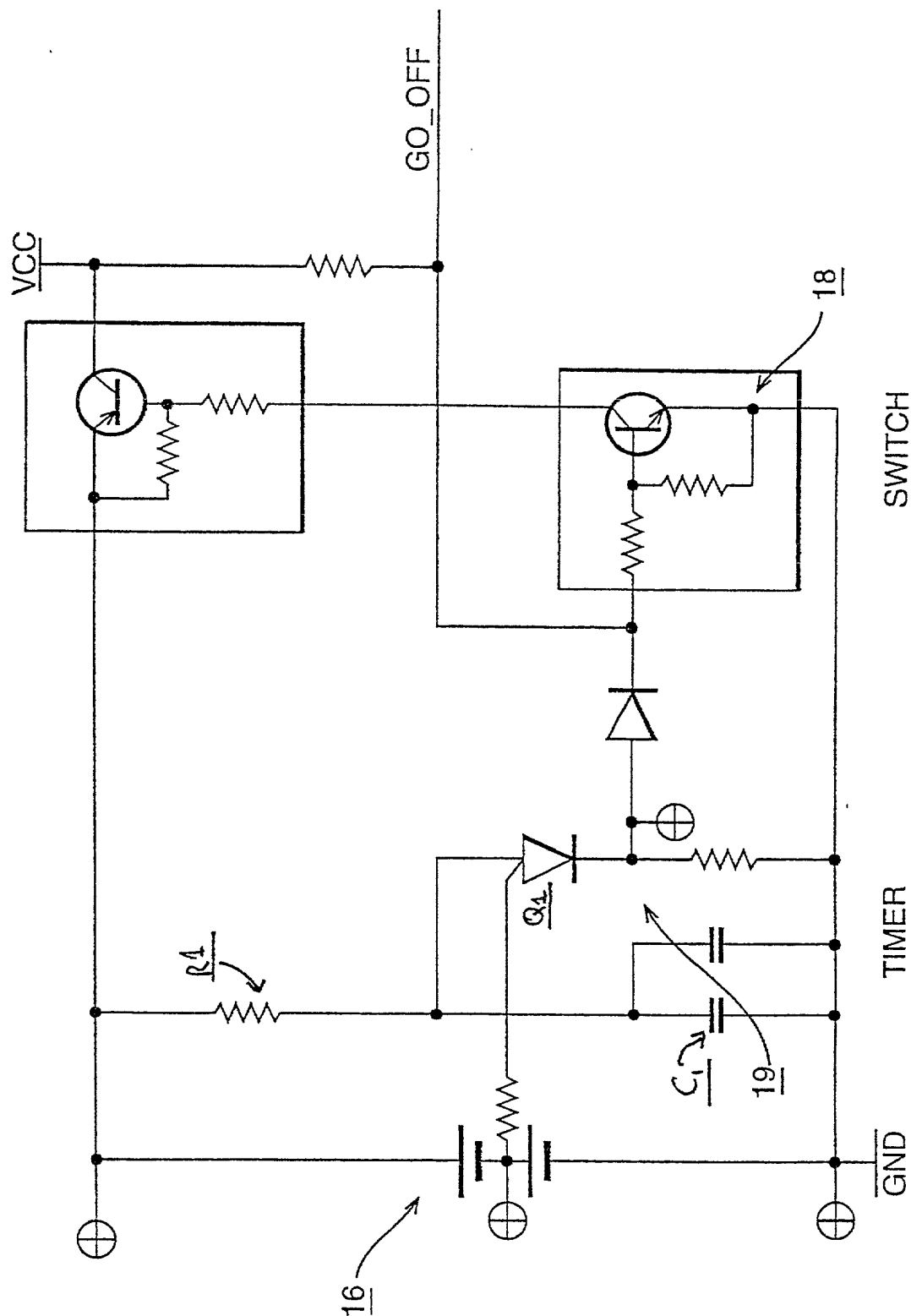


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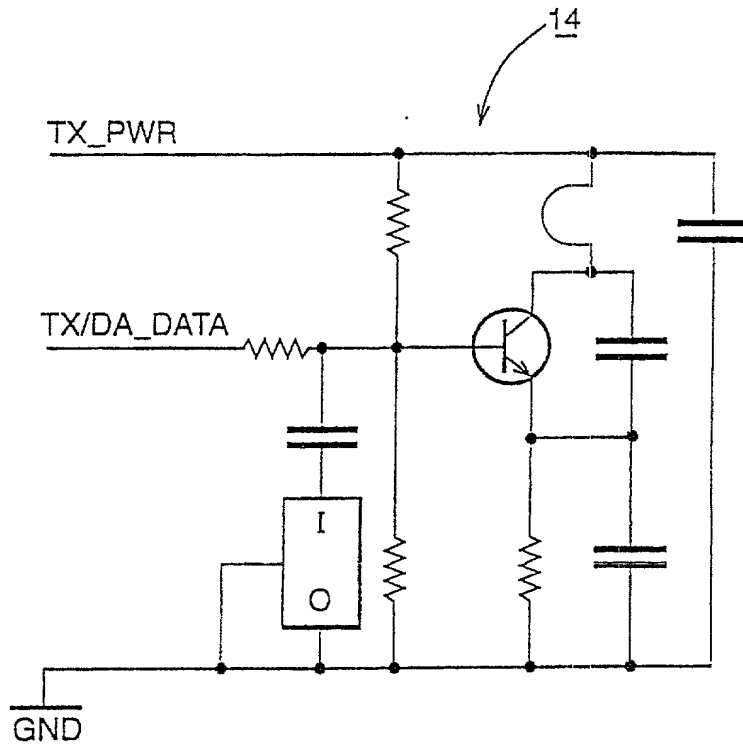
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FIG. 4



**FIG. 5**  
TRANSMITTER AND ANTENNA



**FIG. 11**

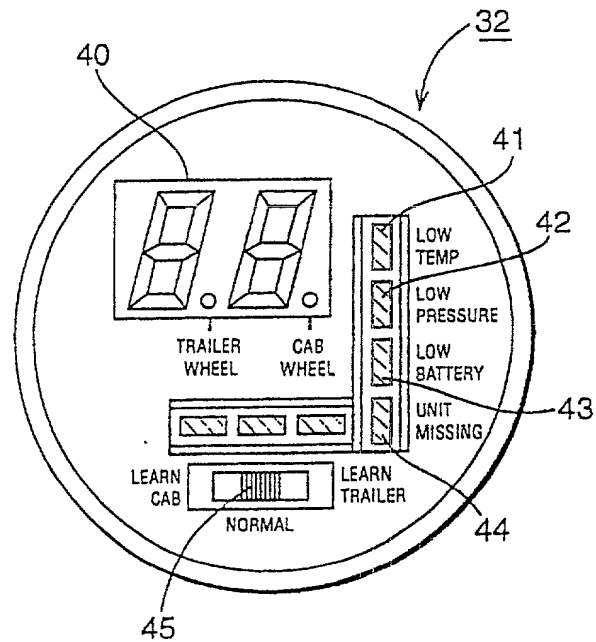
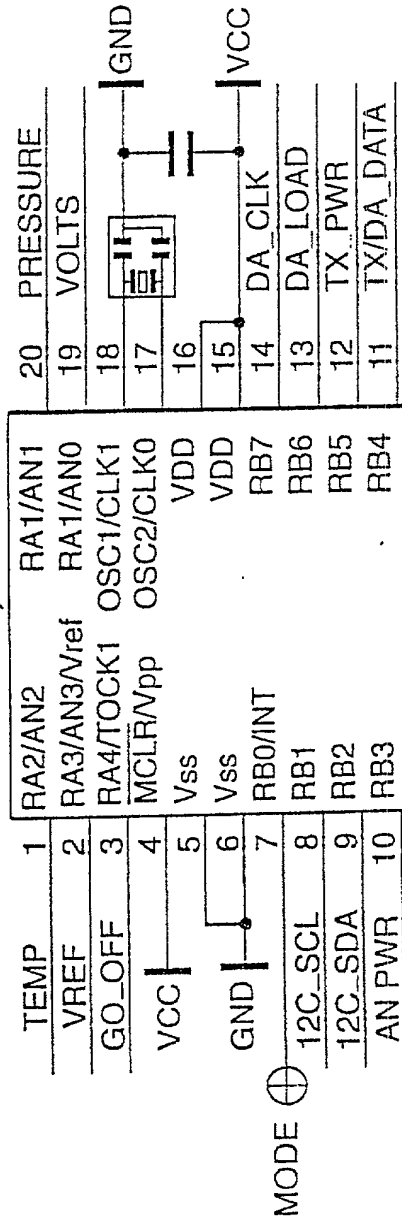


FIG. 7

SYSTEM CONTROL COMPUTER

15





7/13

FIG. 8(A)

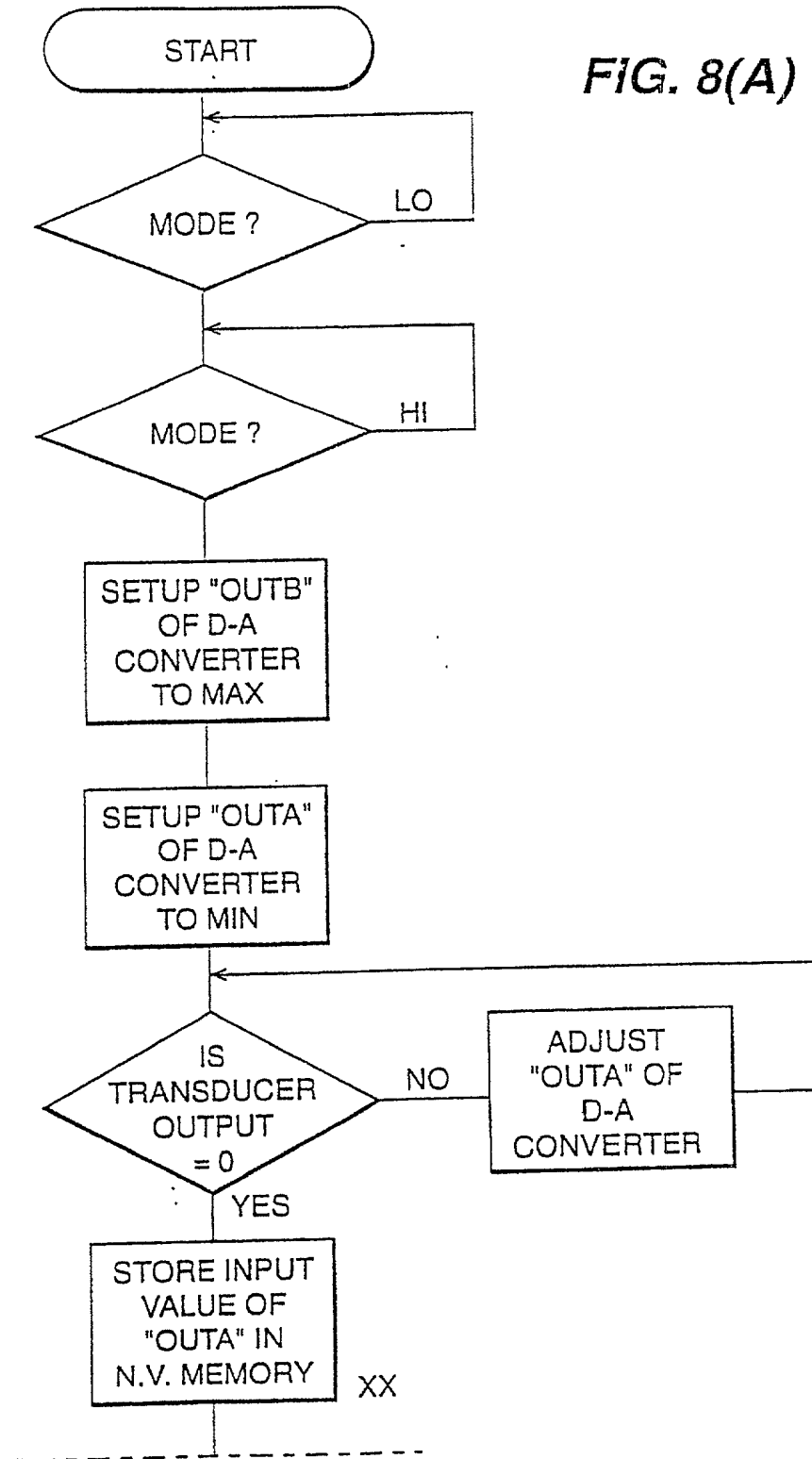
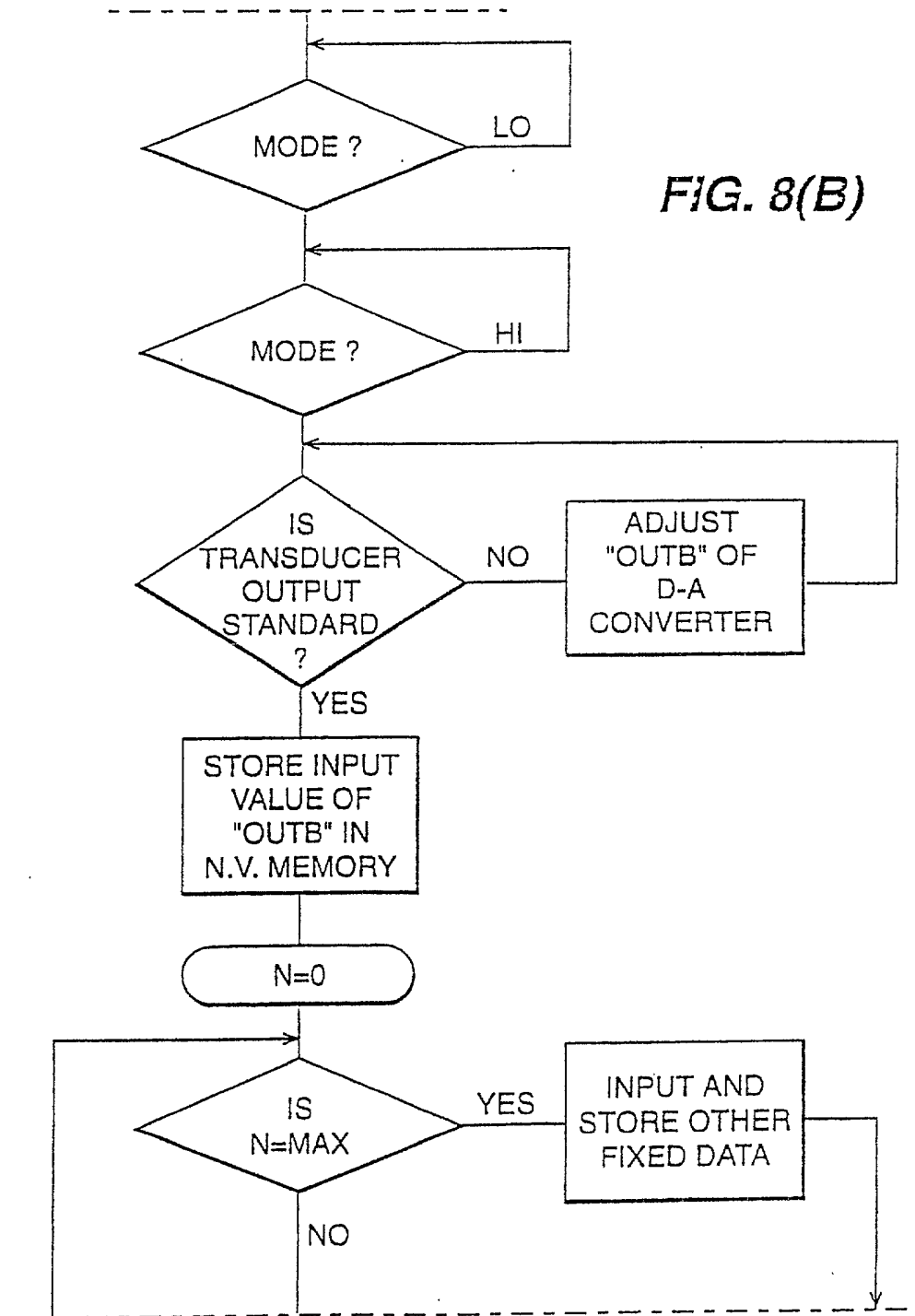


FIG. 8(B)



9/13

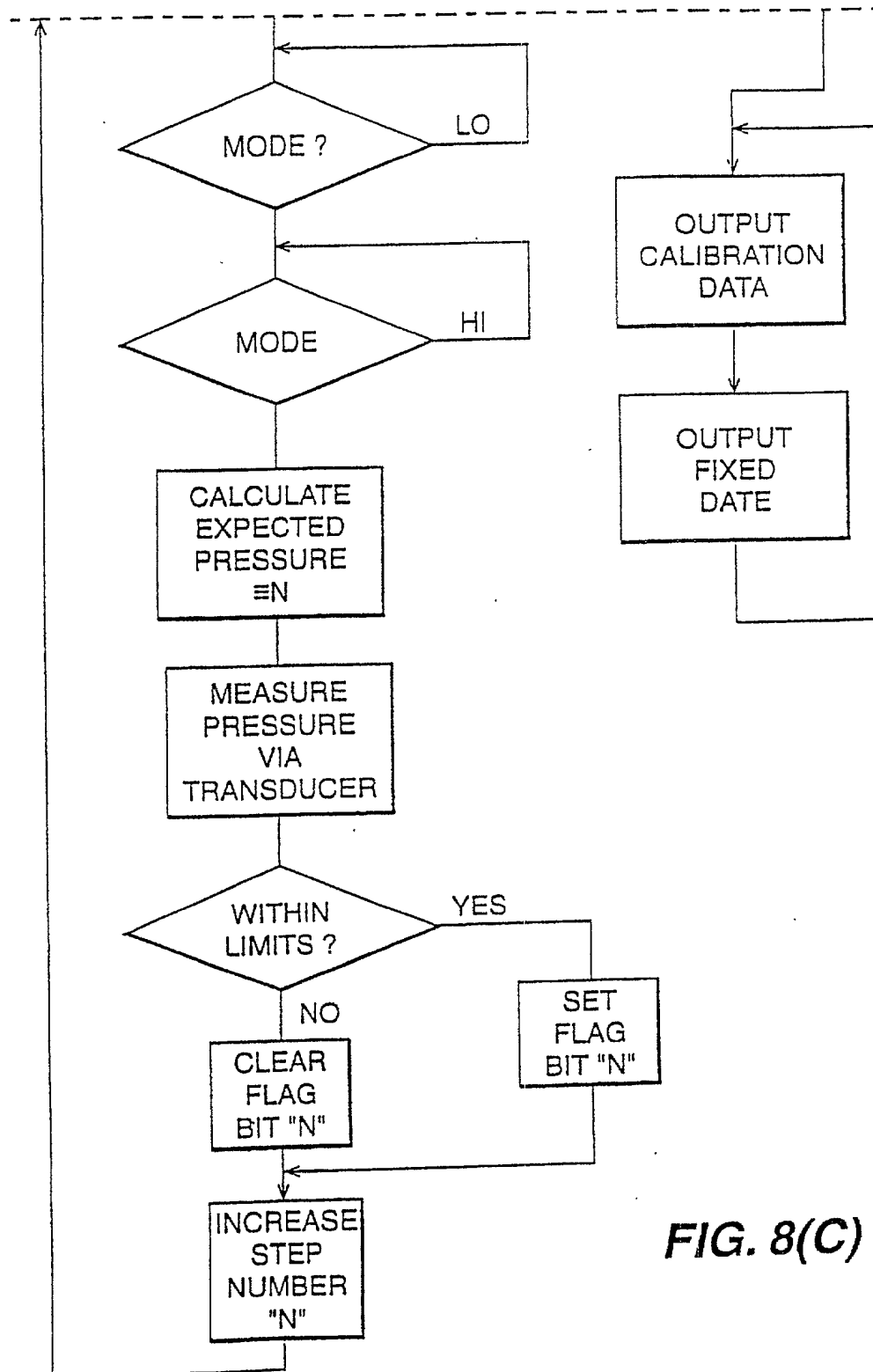
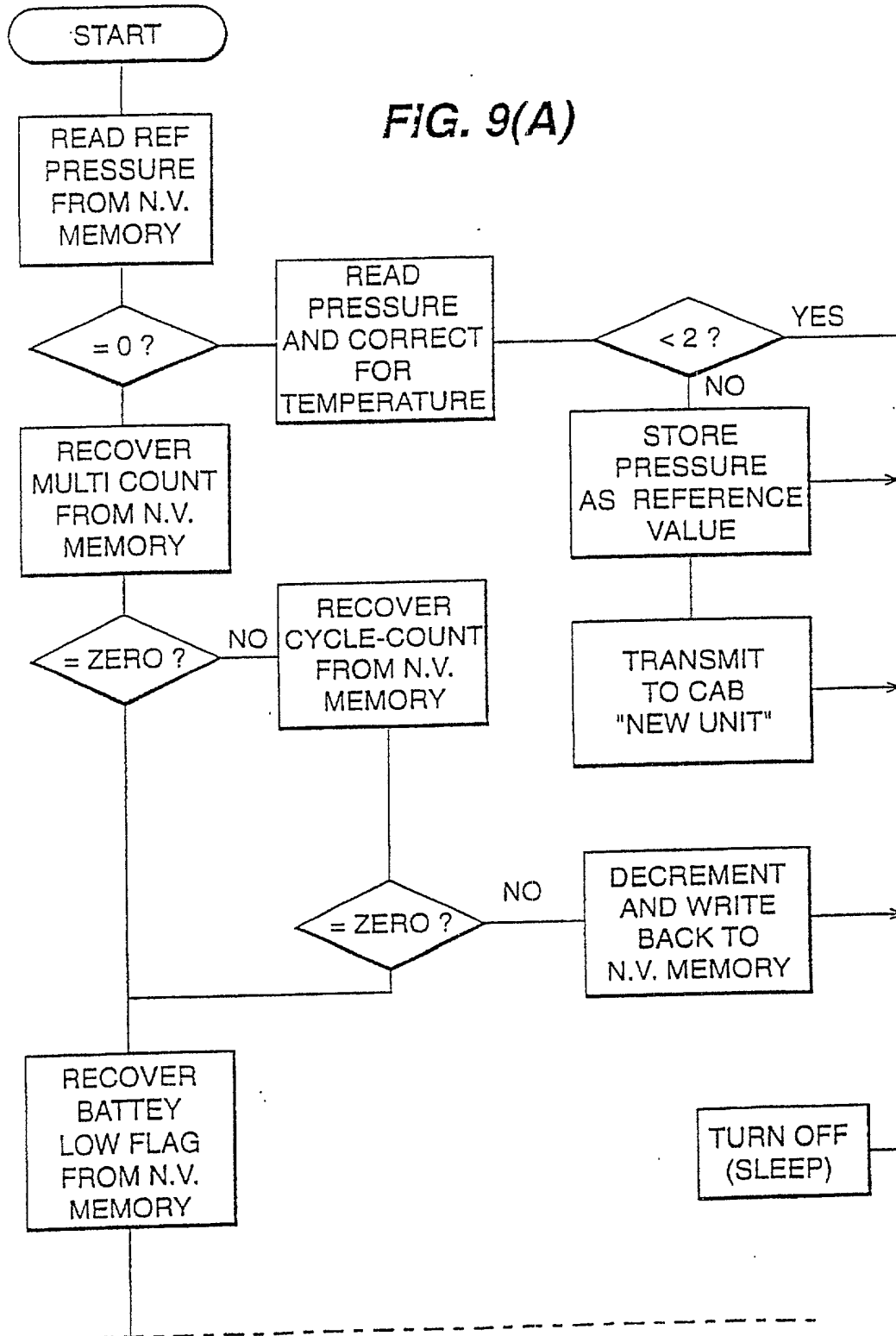
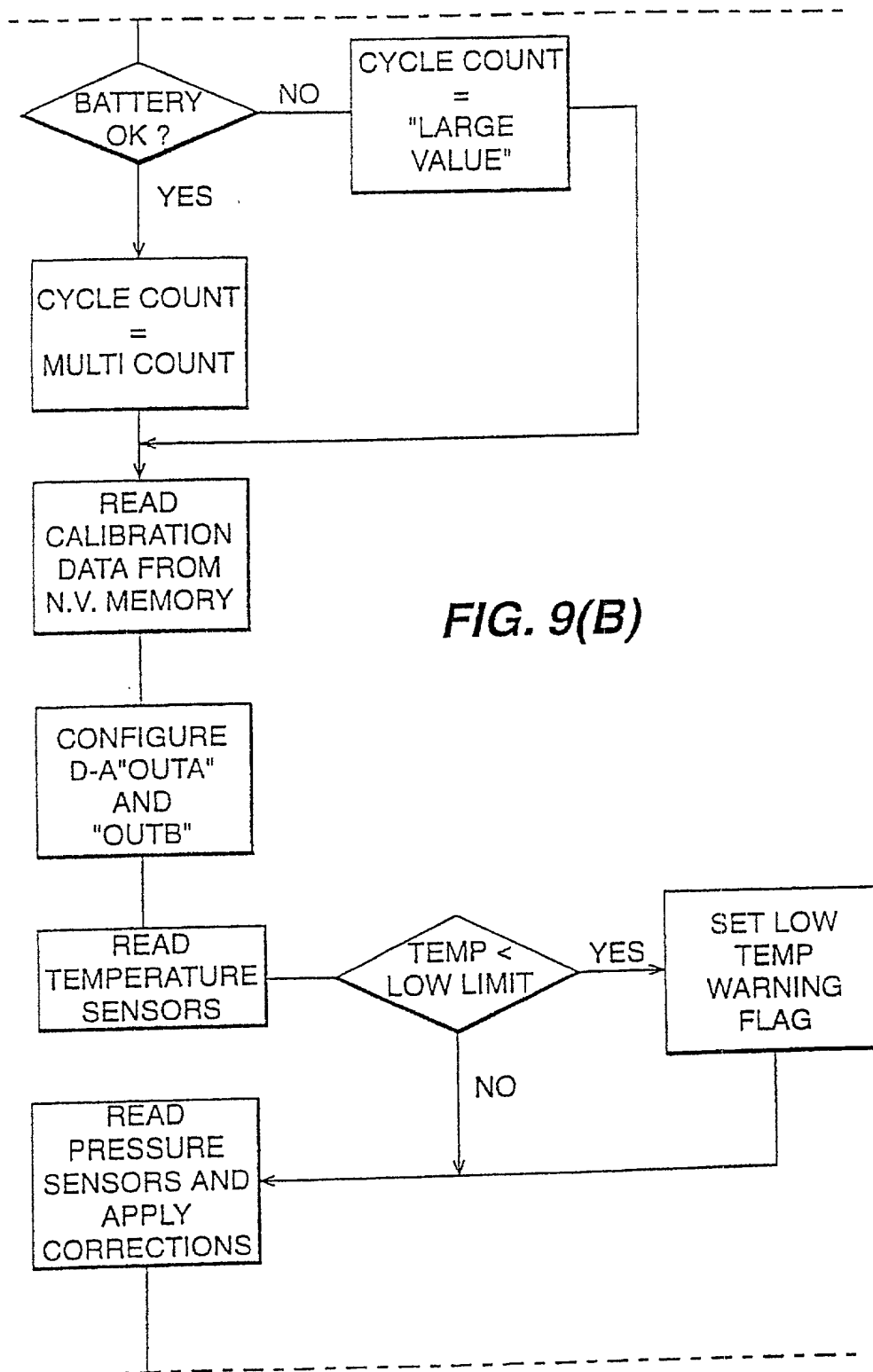


FIG. 8(C)

FIG. 9(A)



11/13



12/13

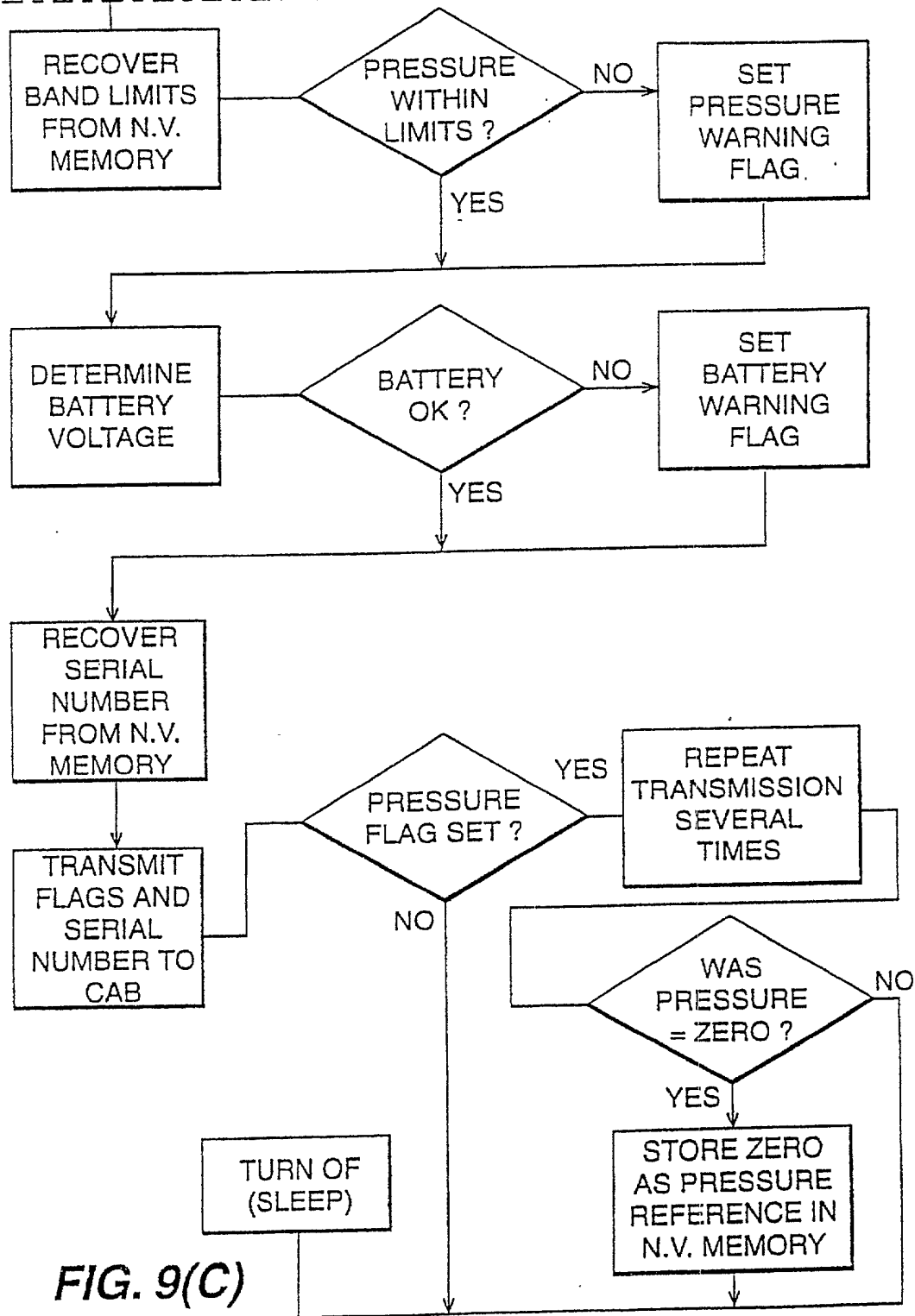
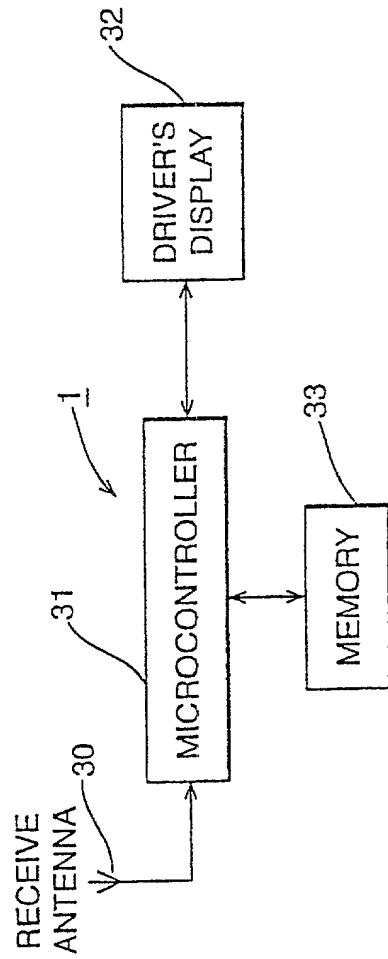
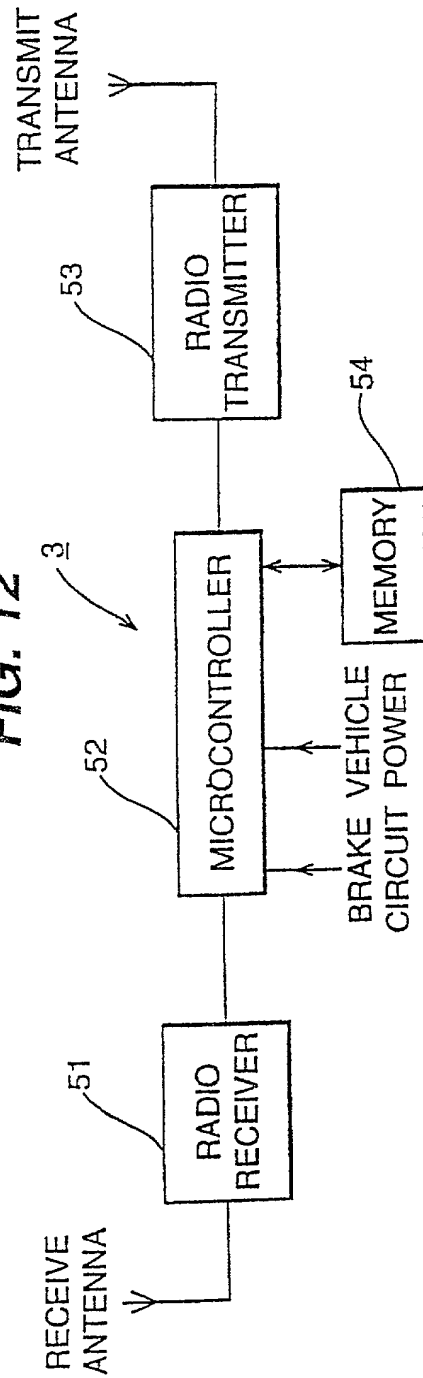


FIG. 9(C)

**FIG. 10****FIG. 12**

Docket No.  
2497/101

# Declaration and Power of Attorney For Patent Application

## English Language Declaration

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

**A REMOTE TIRE PRESSURE MONITORING SYSTEM**

the specification of which

(check one)

☐ is attached hereto.

☒ was filed on May 21, 1999 as United States Application No. or PCT International

Application Number PCT/GB99/01625

and was amended on June 23, 2000

(if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d) or Section 365(b) of any foreign application(s) for patent or inventor's certificate, or Section 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate or PCT International application having a filing date before that of the application on which priority is claimed.

| Prior Foreign Application(s) | Priority  | Not Claimed            |
|------------------------------|-----------|------------------------|
| <u>98 111 54.5</u>           | <u>GB</u> | <u>22/06/98</u>        |
| (Number)                     | (Country) | (Day/Month/Year Filed) |
| <u></u>                      | <u></u>   | <u></u>                |
| (Number)                     | (Country) | (Day/Month/Year Filed) |
| <u></u>                      | <u></u>   | <u></u>                |
| (Number)                     | (Country) | (Day/Month/Year Filed) |



I hereby claim the benefit under 35 U.S.C. Section 119(e) of any United States provisional application(s) listed below:

\_\_\_\_\_  
(Application Serial No.)

\_\_\_\_\_  
(Filing Date)

\_\_\_\_\_  
(Application Serial No.)

\_\_\_\_\_  
(Filing Date)

\_\_\_\_\_  
(Application Serial No.)

\_\_\_\_\_  
(Filing Date)

I hereby claim the benefit under 35 U. S. C. Section 120 of any United States application(s), or Section 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. Section 112, I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, C. F. R., Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application:

\_\_\_\_\_  
(Application Serial No.)

\_\_\_\_\_  
(Filing Date)

\_\_\_\_\_  
(Status)  
(patented, pending, abandoned)

\_\_\_\_\_  
(Application Serial No.)

\_\_\_\_\_  
(Filing Date)

\_\_\_\_\_  
(Status)  
(patented, pending, abandoned)

\_\_\_\_\_  
(Application Serial No.)

\_\_\_\_\_  
(Filing Date)

\_\_\_\_\_  
(Status)  
(patented, pending, abandoned)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. (list name and registration number)

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| Timothy M. Murphy     | <u>33,198</u> | Sonia K. Guterman      | <u>44,729</u>   |
| Robert M. Asher       | <u>30,445</u> | Keith J. Wood          | <u>45,235</u>   |
| Samuel J. Petuchowski | <u>37,910</u> | Karen A. Buchanan      | <u>37,790</u>   |
| Harriet M. Strimpel   | <u>37,008</u> | Yang Xu                | <u>45,243</u>   |
| Steven G. Saunders    | <u>36,265</u> | Alton Hornsby, III     | <u>P-47,299</u> |
| John J. Stickevers    | <u>39,387</u> | Alexander J. Smolenski | <u>P-47,953</u> |
| Herbert A. Newborn    | <u>42,031</u> |                        |                 |
| Jean M. Tibbetts      | <u>43,193</u> |                        |                 |
| Jeffrey T. Klayman    | <u>39,250</u> |                        |                 |
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|                                      |      |
|--------------------------------------|------|
| Full name of second inventor, if any |      |
| Second inventor's signature          | Date |
| Residence                            |      |
| Citizenship                          |      |
| Post Office Address                  |      |